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Evaluation of a Surface Application of Limestone for Controlling Acid Mine Discharges from Abandoned Strip Mines Sewellsville, Ohio

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AN EVALUATION OF A SURFACE APPLICATION OF LIMESTONE FOR CONTROLLING ACID MINE DISCHARGES FROM ABANDONED STRIP MINES, SEWELLSVILLE, OHIO

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The results of this field study and simultaneous laboratory experiments showed that the maximum amount of alkalinity that can be generated by a surface application of limestone is not sufficient to reduce the ground water acidity generated by pyrite oxidation. Additionally, the amount of limestone applied was not sufficient to significantly decrease the rate of pyrite oxidation nor provide neutralization and thereby produce neutral or alkaline discharges from the abandoned coal strip mine sites.

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FOREWORD

When energy and material resources are extracted, processed, converted, and used, the related pollutional impacts on our environment and even on our health often require that new and increasingly more efficient pollution control methods be used. The Industrial Environmental Research Laboratory - Cincinnati (IERL-Ci) assists in developing and demonstrating new and improved methodologies that will meet these needs both efficiently and economically.

Reported here are the results of a study to investigate the effectiveness of the surface spreading of limestone to improve the quality of acid mine discharges from a twelve year old, unreclaimed coal strip mine. These data provide an estimate of the amount of alkalinity which can be generated and the levels of acidity which can be neutralized. Therefore, the results could be applied in the reclamation of abandoned coal strip mines as well as in active operations where acid discharges have developed. For further information contact the Nonferrous Metals and Minerals Branch of the Industrial Pollution Control Division.

David G. Stephan
Director
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ABSTRACT

A 150 acre drainage basin in an unreclaimed coal strip mine in east-central Ohio was studied and extensively monitored to determine the effect of a surface application of limestone on the ground water quality. Prior to the limestone treatment the ground and surface water of the basin was acidic due to pyrite oxidation in the spoil.

In order to assess the effect of limestone application the drainage basin was divided into seven smaller basins, five of which were treated. Various halide salts were also applied in order to ascertain the rate of ground water movement through the spoil. Twenty-six seeps draining the seven basins were monitored on a weekly basis for temperature, pH, acidity, alkalinity, conductivity and the tracers and once a month for sulfate. A recording rain gage was set up in the area and a weekly composite of precipitation was analyzed.

The seeps from the basins with low acid concentrations became alkaline due to neutralization but one seep, after a long dry period, returned to its acid condition. The moderately and highly acidic seeps showed a decline in the acid concentrations which could be attributed to a combination of neutralization and a decrease in the rate of pyrite oxidation.

The results of this field study and simultaneous laboratory experiments showed that the maximum amount of alkalinity that can be generated by a surface application of limestone is not sufficient to reduce the ground water acidity generated by pyrite oxidation. Additionally, the amount of limestone applied was not sufficient to significantly decrease the rate of pyrite oxidation nor provide neutralization and thereby produce neutral or alkaline discharges from the abandoned coal strip mine sites.

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SECTION 1

INTRODUCTION

BACKGROUND OF THE PROBLEM

During coal strip mining operations in the bituminous coal fields of the eastern United States, rocks overlying the coal seams (the overburden) are disturbed. These rocks, containing various mineral assemblages, are broken into varying size fractions and exposed to the atmosphere. The subsequent physical and chemical weathering of the rocks has led to many problems commonly associated with coal mining such as increased stream sedimentation, fugitive dust, unstable conditions within the spoil leading to mass movement and the formation of acid drainages. This study concerns the acid mine drainage problem and the geochemical considerations which should be taken into account for reclamation of the surface and ground water resources.

Acid mine drainage is a high iron and sulfate drainage with a low pH and a high acidity that forms under natural conditions when certain coal seams and overlying rocks are exposed to the atmosphere. The oxidation of iron sulfides, occurring primarily as pyrite or marcasite and which are contained in the coal and overlying strata, can produce acid drainages either by the release of iron, sulfate and acidity directly into or by the initial formation of hydrous iron sulfate salts. The former may be produced when the oxidation occurs in the presence of sufficient water to inundate the pyrite, whereas the latter usually occurs on near surface or exposed rock faces which are subject to wetting and drying events. Some of the oxidation salts have been identified as melanterite (white crystals of ferrous sulfate), copiapite (yellow crystals of ferric sulfate), halotrichite (white crystals of iron and magnesium sulfate), and alunogenite (white crystals of aluminum sulfate). Natural waters flowing over these rocks place the highly soluble salts into solution so that the resultant waters are acidic and contain large amounts of iron and sulfate.

The rocks in the overburden may also contain calcareous material. The dissolution of these minerals, ($CaCO_3$, $MgCO_3$, and $CaMg(CO_3)_2$) by natural waters produce alkaline drainages with attendent amounts of calcium and magnesium. The rate of dissolution of calcareous material is dependent on the rate of water flow and the frequency of contact between the water and the minerals (Rauch and White, 1977; Geidel, 1979). The solubility of these carbonates is dependent on the partial pressure of carbon dioxide (P_{CO_2}) so that even though the rate of dissolution may be relatively rapid, and near-equilibrium conditions are attained quickly, the system has a low equilibrium solubility at atmospheric P_{CO_2}.

In areas where the environment of coal deposition also produced abundant alkaline-producing strata, the formation of acidic drainages following the disturbance of these rocks is minimal (Caruccio, et. al., 1977). This tends to suggest that the presence of, and perhaps introduction of, alkaline material in an area may decrease the acid potential or at least be an effective neutralizing material.

STATEMENT OF OBJECTIVES

During the past fifteen years, major advances have been made in the field coal mine drainage research in terms of predicting the expected surface and ground water quality as a result of surface mining in the eastern U.S. bituminous coal reserves (Caruccio, 1968, 1975; Caruccio et. al., 1977, 1978, 1981; Singer and Stumm, 1970; and Sobek et. al., 1978). Some of these studies have dealt with only the single facet of the rock characteristics while others recognized the interactions of ground water geochemistry, rock characteristics and the chemical variations in the rock-water interactions. Therefore, one of the objectives of this study is to provide a brief summary of the principal factors affecting mine drainage quality.

The major objective of this study, however, was to ascertain the extent to which acid mine drainage can be abated or neutralized by the alkalinity generated from limestone dissolution. The working hypothesis of the study was that the application of crushed agricultural limestone on the surface of mine spoils might inhibit the oxidation of pyrite by maintaining an alkaline environment or might neutralize some of the acid subsequently produced. To test this hypothesis, an abandoned strip mine in east-central Ohio was divided into small drainage basins and treated with various tonnages of crushed limestone. Seeps emanating from the basins were monitored for pH, sulfate, acidity, alkalinity, temperature and specific conductance in order to ascertain the effects of the various treatments. Concurrent with the limestone application, various halide salts were applied in order to ascertain the direction and rate of ground water movement through the spoil.

SECTION 2

SUMMARY AND CONCLUSIONS

SUMMARY OF METHODOLOGY

A 60 hectare (150 acre) drainage basin in a portion of a twelve year old, partially reclaimed coal strip mine in east-central Ohio was studied and extensively monitored to determine the effect of a surface application of limestone on degraded ground and surface water quality. During the mining operation, the overburden which consisted primarily of a sandstone containing pyrite nodules and lenses was disturbed and exposed to the atmosphere. Due to the porous nature of the sandstone, a ground water system was established and as the pyrite nodules oxidized, the ground water, as well as the surface water, became acidic with high levels of iron and sulfate. Additionally, many areas could not be revegetated due to the toxic nature of the surface material.

During the fall of 1978 and the spring of 1979, twenty-five seeps in the drainage basin were identified and chemically analyzed. The drainage basin was divided into seven small basins based on topography and the geochemical similarity of seeps. Within each basin, the seeps were of approximately the same quality and these similarities served to better define the basins. These areas were surveyed in the field and the boundaries marked.

Five of the basins (basins 1 through 5) were treated with a less than 8 mesh agricultural limestone and 2 basins (basins 6 and 7) were left untreated as control sites. The limestone material which was a dolomitic, high magnesium limestone was provided and transported by the Bedway Coal Company of Adena, Ohio. The material was spread by a 4 wheel drive spreader truck at rates of 80 metric tons/ha (36 tons/acre) to 150 metric tons/ha (67 tons/acre).

Concurrent with the limestone application, designated areas of each basin were spiked with one of three tracers: iodide, bromide, or fluoride. The tracer which was applied at a depth of approximately 15 cm. (6 in.), served three functions. First, the rainfall infiltrating through the spoil, would contact the tracer and when the tracer was detected in the seep, the quality of that particular seep was being affected by the limestone application. Secondly, by placing different tracers in adjacent basins, the flow paths of water could be traced and the source of the seep was defined. In one basin (basin 4) which appeared to be hydrologically isolated from the rest of the basin, all three tracers were applied. Tracing these spikes allowed the hydrology at this site to be determined.

The seeps were monitored on a weekly basis and samples from all flowing seeps were collected, analyzed immediately for pH and alkalinity and shipped to South Carolina for further analysis.

SUMMARY OF RESULTS AND CONCLUSIONS

The weekly analysis of twenty-five seeps from June 1979 to August 1981 showed that within the control basins, there was a slight decrease in acidity with time even though no surface ameliorants had been added to the basin. In the high acid basins (basins 1, 3, and 5) the amount of alkalinity generated by the surface application of limestone was not sufficient to reduce the acidity of these seeps significantly. However, the decrease in the acidity and sulfate levels from the seeps in these basins was greater than the decrease in the control seeps. This was attributed primarily to a decrease in the rate of pyrite oxidation. Neutralization appeared to be a secondary source of decreased acidity, but there was evidence of neutralization occurring in one seep in basin #5 based on the acidity-sulfate ratios.

In the moderately acidic basin (basin #2), there was also a decrease in the acidity levels in the seeps but the decrease in both acidity and sulfate were not significantly different than the decreases in the control sites. Because the tracer was never detected in this basin, it is possible that insufficient time had elapsed for the seep to be affected by the limestone treatment.

In basin #4, where the seeps were initially low acid, the alkalinity generated by the limestone was sufficient to neutralize two of the three seeps to produce net alkaline drainages. However,only one of the two seeps remained alkaline; the other became acidic after a drought. The initial acidity of seep 18 which remained alkaline, was approximately 50 to 70 mg/l and after neutralization, the net alkalinity was between 30 and 40 mg/l. Of the two other low acid seeps, which were initially slightly higher in acidity (70 to 150 mg/l), one became alkaline due to neutralization but, after a drought, returned to acidic state probably due to the build up of acid salts during the drought. Except during the period when the seep actually was alkaline and the acidity was being neutralized, the overall decrease in acidity and sulfate for these two seeps was not significantly different than the decrease in the control seeps.

Therefore, the surface application of a dolomitic limestone was not found to be an effective means of reducing the acidity of an established acidic ground water system. Although this study showed that the limestone was able to slightly decrease the rate of pyrite oxidation and did afford some neutralization, the overall improvement of the recipient stream was minimal. The stream pH remained relatively low (between pH 2.8 and 3.2) and the acidity levels were still high (300 - 600 mg/l).

SECTION 3

FACTORS AFFECTING MINE DRAINAGE QUALITY

RATE OF ACID PRODUCTION

Presence of Pyrite

The general chemical relationships for the oxidation of pyrite (FeS_2) and the production of acidity are given by the following equations:

$$FeS_{2(s)} + 7/2\ O_2 + H_2O = Fe^{2+} + 2\ SO_4^{2-} + 2\ H^+ \qquad [1]$$

$$Fe^{2+} + \tfrac{1}{4}O_2 + H^+ = Fe^{3+} + \tfrac{1}{2}H_2O \qquad [2]$$

$$Fe^{3+} + 3H_2O = Fe(OH)_{3(s)} + 3H^+ \qquad [3]$$

$$FeS_{2(s)} + 14Fe^{3+} + 8H_2O = 15Fe^{2+} + 2SO_4^{2-} + 16H^+ \qquad [4]$$

(Barnes and Romberger, 1968)

In equation [1], 1 mole of pyrite in the presence of oxygen and water will oxidize and release 1 mole of ferrous iron and two moles of both sulfate and hydrogen ions (acidity). The ferrous iron is then oxidized to ferric iron in equation [2] and can form a hydroxide, as indicated in equation [3]. Pyrite oxidation can also occur in the presence of excess ferric iron as in equation [4]. Singer and Stumm (1970) report that equation [2], iron oxidation, is the rate limiting step of the reaction and procedes slowly under sterile conditions. However, microbial action by iron oxidizing bacteria greatly enhance the ferrous iron oxidation and, therefore, serve as catalysts for equation [4] (US EPA, 1971; Kleinmann, 1981).

The pyrite morphology has also been shown to play a major role in the pyrite oxidation rates (Caruccio, 1968, 1975; Micheal, 1980). Coarse grained pyrite (greater than 100μ) and pyrite replacing plant structures are the least reactive of the sedimentary pyrite forms. These are usually considered to be secondary pyrite which formed after the coalification processes. Euhedral crystals, framboidal clusters, and mossy-pitted pyrite are primary pyrite forms deposited syngenetically with the coal. Of the three primary forms, framboidal pyrite which is a spherical cluster of small (<1μ) grains, is the most reactive and has been shown to oxidize more readily than the others.

Presence of Bacteria

As mentioned above, the presence of bacteria is also an important factor in acid production. Two bacteria: the thiobacillus thiooxidans, sulfur-oxidizing bacteria; and the thiobacillus ferrooxidons which oxidize ferrous iron to ferric iron have been isolated from the acid mine drainage environment and have been shown to have a catalyzing effect on the oxidation reactions (Silverman, 1967). The thiobacillus ferrooxidons play an important role in catalyzing the ferrous to ferric iron reaction and are viable in the pH range of 1.8 to 5.5 (Razzel and Trussel, 1962), although their optimum survival rate occurs between pH 2.8 and 3.2 (E.P.A., 1971). This suggests that once pyrite oxidation occurs and lowers the pH of the system, the bacteria are viable and if present, will increase the rate of acid production.

The factors mentioned thus far have only taken into account those elements which affect the rate of acid production. There are many other geologic conditions which also play an important role in the ultimate quality of the mine drainage.

Presence of Carbonate

The oxidation of pyrite is also affected by the presence of carbonate. Temple and Koehler (1954) showed that calcium and magnesium (presumably as a calcium-magnesium carbonate) were present in stable pyrite nodules but absent in the reactive ones. However, after the nodules were immersed in a mild hydrochloric acid solution, which dissolved the carbonate, the stable nodules began to oxidize. This suggests that once acidic waters are formed, the pyrite is effectively stripped of its protective carbonate and pyrite oxidation is enhanced. Additionally, Caruccio, et. al., (1981) showed that rock samples containing both significant amounts of carbonate and pyrite did not produce acidity during simulated weathering tests until the carbonate had been leached out of the sample. This further indicates that the carbonate may have an inhibitory effect on the oxidation of pyrite.

A study recently completed by Burt (1981) showed that alkaline waters draining through acid producing pyrite, neutralized an amount of acid equal to the alkalinity introduced. There were, however, no indications that the alkaline waters were inhibiting the pyrite oxidation. He also showed that limestone added to and mixed with pyrite grains, initially neutralized acid when water contacted the material but sulfate values of the leachate were high which indicated that acid was being produced and neutralized, and that the limestone was not inhibiting pyrite oxidation. The same study also showed that the calcium and magnesium contents of the leachates decreased with time and that minimal amounts of iron were present in the leachate. This strongly suggested that the iron was precipitating on the limestone and that with time, the limestone would become coated and would not be available for alkalinity production.

Therefore, it is suggested that when calcareous material occurs syngenetically with the pyrite, the carbonate may inhibit pyrite oxidation until the carbonate has been dissolved by natural processes. However, calcareous material which is introduced into an acid system, can serve only to neutralize the acid produced and will only be effective for as long as the limestone remains uncoated with iron.

Permeability of the Backfill Material

The permeability of the spoil or backfill material is an important factor because it directly affects the availability of water, the flow rate and the frequency of wetting fronts migrating through the spoil material. Based on equations [1] and [4], oxidation cannot occur in the absence of water. Water usually migrates into the backfill in two ways; from the downward migration of precipitation and/or from the lateral movement of water from the buried highwall. Current laws require that spoil be placed against a cut highwall and that the slope be returned to original contour. Therefore, water which seeps out of the highwall becomes incorporated in the backfill.

The rate of water movement through the backfill will affect the concentration of parameters associated with mine drainage (sulfate, iron, acidity, etc.). However, the loads of the chemical constituents (expressed on a weight rather than a weight per volume basis) will remain the same regardless of the flow rate (Rice 1971). If the permeability of the backfill is low, during a long duration rainfall event, the water will percolate to a certain depth and if that depth is above the water table, the water will not continue to flow but will be retained as soil moisture. The pyrite will begin to oxidize, and the weathering products will continue to accumulate until the next wetting front places the salts into solution and carries them from the production site. In this case, the rate of acid production is not only dependent on the flow rate but also on the time between flushing intervals; the greater the time interval, the greater the acid load (Geidel, 1979).

If the backfill has a high permeability, precipition events may flush the accumulated salts on a much more frequent basis leading toward higher flow rates and lower acid concentrations than from a backfill with a low permeability where low flow rates and high acid concentrations would be expected.

Pore Gas Content

The dissolved gas content is in many ways tied to the permeability of the backfill. The greater the permeability, the greater the initial or trapped oxygen level in the spoil. However, in some cases where shales comprise a majority of the overburden, the permeability may be low due to the friable nature of many shales. The oxygen reserve level is lower and the acid production, which is directly proportional to the partial pressure of oxygen may be minimized. Rice (1971) showed that nitrogen, methane, and carbon dioxide reduced the rate of pyrite oxidation. Although it is uncommon to find high concentrations of nitrogen and methane in strip mine pore gases, carbon dioxide may become a major component of the pore gas. Black (1957) suggests that the partial pressure of carbon dioxide could increase to as high as $10^{-1.0}$ atm. when a good soil mulch has developed.

This is significant in view of Rice's findings that CO_2 decreased the amount of acid produced.

PRODUCTION OF ALKALINITY

Carbonate Solubility

The dissolution of calcareous material releases cations (predominantly Ca^{++} and/or Mg^{++}) and alkalinity, in the form of bicarbonate (HCO_3^-) or carbonate ($CO_3^=$). The calcareous material, in the form of either limestone, dolomite or calcareous cement in shale or sandstone is naturally occurring in strata associated with the coal fields and is the primary, although not sole, contributor to alkalinity in the drainages and streams. Limestone, as $CaCO_3$, when placed in an aqueous environment at atmospheric conditions achieves solubility equilibrium conditions rapidly (Plummer and MacKenzie, 1974). However, when the alkalinity available under equilibrium or saturated conditions is compared to the acidity produced by FeS_2 oxidation, the alkalinity is minimal.

The solubility of the calcium carbonate is dependent on the partial pressure of carbon dioxide (P_{CO_2}), pH, temperature and the length of time that water is in contact with the material. At a P_{CO_2} of $10^{-3.5}$ atm., atmospheric conditions, the molar concentration of bicarbonate alkalinity at equilibrium conditions is $10^{-2.9}$ or approximately 75 mg /l as HCO_3^- or 125 mg /l as $CaCO_3$ with a equilibrium pH of 8.4.

Another common source which contributes to the formation of alkalinity is dolomite ($CaMg(CO_3)_2$). Equilibrium conditions are also rapidly achieved but the maximum alkalinity available is much less than that from limestone. Using a calculated equilibrium constant (K) of $10^{-19.71}$, the alkalinity which can be generated from the following equation:

$$CaMg(CO_3)_2 + 2\ CO_2 + 2\ H_2O \rightarrow Ca^{++} + Mg^{++} + 4\ HCO_3^- \qquad [5]$$

is 25 mg/l as HCO_3^- (or about one third that of limestone) and has an equilibrium pH of 7.9.

Because one of the factors affecting the solubility of the calcareous material is the P_{CO_2}, changes in the P_{CO_2} will change the equilibrium alkalinity values. One way of producing higher carbon dioxide levels is through the respiration activity of microorganisms in the soil and by the decay of organic matter, such as in a soil mulch which has developed as a result of extensive vegetation. Rainwater or surface water coming in contact with these zones of high CO_2 will pick up the increased CO_2 levels and subsequent contact with calcareous material, prior to CO_2 exsolution, will increase the equilibrium alkalinity. Data from Black (1957) suggest that a P_{CO_2} level of 10^{-1} could exist under the aforementioned circumstances, resulting in an alkalinity increase of up to 8 times.

The rate of water movement through alkaline producing material and the time interval between wet and dry periods also affects the total alkalinity production. Unlike the acid producing reactions where the FeS_2 continues to oxidize in a moist environment and the acidity accumulates with time, in an alkaline system, the material very quickly achieves equilibrium in a moist environment and within one day, no additional alkalinity builds up (Geidel, 1979). Therefore, if the period between the leaching of calcareous material exceeds one day, the amount of alkalinity released will be the same. However, if acid materials are subjected to similar conditions, the longer the time interval between the leaching the greater will be the acidity.

Another common carbonate in the strata associated with coal is siderite, $FeCO_3$. This mineral, however, does not react in a manner similar to $CaCO_3$ because the iron, after it is released, oxidizes and produces acidity as shown in the following reactions:

$$FeCO_3 + H^+ = Fe^{++} + HCO_3^- \qquad [6]$$

$$Fe^{++} + \tfrac{1}{4}O_2 + H^+ = Fe^{+++} + \tfrac{1}{2}H_2O \qquad [7]$$

$$Fe^{+++} + 3H_2O = Fe(OH)_3 + 3H^+ \qquad [8]$$

(Garrels and Christ, 1965)

This shows that the oxidation of iron results in the net release of one mole of acidity for each mole of siderite dissolved and that the dissolution of siderite does not contribute to the overall release of alkalinity.

Shales within the sedimentary sequence contain two components which may neutralize acidity. The first is the presence of a calcareous matrix. As the shale is broken and crushed, the calcareous material, which may be present as a calcium or calcium-magnesium carbonate, can be used to neutralize acidity. The second component is the cation-exchange capacity of the clays within the shale. The clays will exchange surface and interlayer cations with cations in solution, including H^+. As more bonds are broken, the crystal lattice is weakened, and the shale decomposes to expose more sites for exchange.

Silicate Solubility

The dissolution of silicates also can also neutralize acidity and in some cases produce alkalinity as silicates react with water and carbon dioxide. There are eight major groups of silicates: feldspars, pyroxenes, amphiboles, the olivine group, garnet group, epidote group, mica group and the clays. There are several other groups including the feldspathoids, pyroxenoids, tourmaline group, serpentine minerals and the zeolites. However, the first eight categories are the most common silicate groups, and within the sedimentary sequence only three are predominant; the feldspars, micas and clays. Quartz is present but is relatively stable under the conditions at a mine site.

The feldspar group is composed of several minerals, three of which constitute the majority of feldspar minerals found in nature. They are: orthoclase, a potassium rich feldspar; albite, a sodium rich feldspar; and anorthite which is calcium rich. The dissolution of orthoclase and the resulting reaction and dissolution paths vary among authors, but in the presence of carbonic acid, potassium, bicarbonate and other species will be released or precipitated. According to Stumm and Morgan (1970) and from data derived from Garrels (1957), the concentration of HCO_3^- from orthoclase at equilibrium conditions is approximately 50 mg/l. However, in the presence of sulfuric acid, the reaction would consume acidity and generate sulfate. Each mole of orthoclase could consume and neutralize two moles of acidity. However, the rate data is limited for this mineral and the length of time required for equilibrium conditions to be attained has not been discerned.

Albite, another feldspar, is present in many granitic bodies and may be present in conglomeratic sedimentary rocks. Research concerned with the dissolution of albite has shown that the amount of alkalinity generated at $P_{CO_2} = 10^{-3.5}$ atm. and at equilibrium conditions is approximately 30 mg/l as HCO_3^-. Paces (1973) has shown that in as short a time as 14 days, some leaching of albite has occurred but, after 3000 days, equilibrium conditions may not yet be established. Therefore, although albite would theoretically release as much alkalinity as dolomite, the rate of release for albite is much slower. In this feldspar, the consumption of acidity by the exchange of H^+ for inter-layer cations of albite will also provide neutralization.

The third feldspar, anorthite, is rare in sedimentary sequences but, when present, it could release calcium, bicarbonate and other clay species in the presence of water and carbonic acid. Jackson et. al. (1948) and Stumm and Morgan (1970) suggest that the thermodynamic order of succession of minerals in the weathering sequence is: $CaCO_3$, followed by Ca-feldspars, K-feldspars, and finally Na-feldspars. Although this describes which minerals would probably dissolve first, it does not provide a rate for the feldspar dissolution.

GROUND WATER GEOCHEMISTRY

In the previous discussion, the carbonate and pyrite contents of the rocks were discussed as criteria to predict the quality of drainages. One major factor which has an equally important role in the resultant drainage is the ground water geochemistry. After the mining and backfilling phases of an operation have been completed, the ground water will eventually be reestablished. If the mining method was not mountain top removal, the ground water of the backfill will be composed, at least in part, of ground water seepage from the highwall. The ground water may be alkaline, acidic or nearly distilled. As previously discussed, the alkalinity of ground water is dependent on the P_{CO_2} and the quality of the carbonate material through which the water flowed. Ground water flowing through carbonate terrains has been reported to have alkalinities as high as 400 mg/l as $CaCO_3$.

The magnesium content of the calcareous material will also affect the alkalinity of the ground water. Calcium carbonate with 1 to 2.5% MgO will be readily dissolved in the ground water. However, pure dolomite will be much more slowly dissolved (Rauch and White, 1977) and a much greater time will be required for the system to approach equilibrium conditions.

The ground water in the area surrounding the mine could be slightly acidic with iron and sulfate in solution. This condition is usually indicative of a lack of alkaline material in the geologic section and due to the low pH values associated with these water; iron oxidizing bacteria may also be present. If the bacteria are introduced into an area such as a backfill where many new sites of pyrite oxidation are present, the acid production becomes greatly enhanced.

A third type of ground water which may be present is characterized by a very low specific conductance and a pH between 4.5 and 6.0. This water, which is relatively pure has neglible amounts of acidity or alkalinity and will be readily affected by either acidic or alkaline conditions. This water is characteristic of an environment of deposition which has minor amounts of calcareous material and pyritic material. The undisturbed rocks are in a very delicate balance between the acid and alkaline production potentials. Disrupting the material and allowing this water to flow through the backfill usually weights the balance toward the acid production.

The three types of ground water represent the three end members of the ground water regime. Various interactions between the three types will result in a variety of water qualities. Pure ground water may encounter calcareous material in the backfill material which would result in an alkaline system which has high alkalinity and low sulfate concentrations, less than 10 mg/l. An alkaline ground water system may encounter acidic drainages in the backfill and the reactions could produce an alkaline drainage with a high sulfate concentration or the acidity could overwhelm the alkalinity and result in acid waters with sulfate. Finally, at the end of the spectrum would be pure ground waters coming in contact with acid waters produced in the backfill producing acidic, high sulfate drainages.

RAIN WATER CHEMISTRY

The rainfall chemistry affects the drainage quality because in many mining operations where the backfill material is not greatly compacted, the rainfall will infiltrate and may constitute a significant proportion of the recharge to the reestablishing ground water table. In the northeastern United States, the rainfall is acidic, 5 to 25 mg/l acidity as $CaCO_3$, with pH values usually less than 5 (Galloway *et*. *al*., 1976 and Cogbill and Likens, 1974). These results are consistent with results obtained during this study in east central Ohio and other studies conducted in southwestern Pennsylvania.

The acid nature of the rain has an effect on the rocks similar to that of acidic ground water. Acid rain coming in contact with the rock will more readily dissolve calcareous material, and it may provide a medium in which iron-oxidizing bacteria can survive which will increase the rate of pyrite oxidation.

HYDROLOGY

The hydrology of a mining site affects the drainage quality because it affects the method or mode of rock-water interactions. The hydrology is dependent on several factors, some of which have already been discussed, which include the permeability of the backfill, nature of the underclay, mining technique, rate of water movement and sources of water.

The three main sources of water are from highwall bleed, the infiltration of precipitation and the upward movement of water through cracks in the underclay. In many areas of the Appalachian coal fields, the latter is rarely the primary source of water because the ground water aquifers immediately below the coal are rarely artesian. However, in some of the mines in the Illinois Basin, where the geology necessitates digging pits to remove the coal, artesian systems could be an important source of water. Most of the mines in Appalachian coal fields receive their primary sources of water from either highwall seepage or precipitation infiltration and the percentage contribution of each source will depend on the individual site conditions. Areas with steep slopes and a large highwall face tend to have reduced surface infiltration and increased highwall seepage. Alternatively, areas with low slopes and/or where mountain top removal has occurred are primarily recharged by precipitation infiltration. Naturally, between these two extreme topographic examples the percentage contribution of both sources will vary greatly.

The infiltration depends not only on the slope of the backfill but also on the permeability of the material. During most mining operations, the larger rocks tend to be at the base of the spoil and therefore, this area has the greatest permeability. Water seeping in from the highwall will then flow down the face to the underclay, at which time it will begin to either pool or flow laterally depending on the dip of coal. If there is a slight dip toward the highwall, the water will pool and begin to fill the voids between the rocks. The water will continue to mound and increase in area until the water is discharged from the side of the mine. The permeability will determine the volume of water retained within the spoil. Alternatively, the surface permeability will determine the infiltration of surface water. In areas of Ohio where permeable sandstones are the surface material, the infiltration rates are large. In other areas where compacted shales are the top of the spoil, the surface infiltration is very low.

The mining technique is important to the hydrology because it determines the compaction of the surface material, the configuration of the spoil material and whether mining progresses in an up-dip or down-dip direction.

The overall hydrology of an area affects the drainage quality because it determines the extent of water-rock interactions. If the hydrology allows very little association between the minerals and the water and it is a relatively dry backfill, then, there will be little drainage and the water may not contact pyritic material. Conversely, spoil material which is saturated with ground water and from which flow from the seeps is high, would have a greater probability for acidic drainages if alkaline material was absent and pyritic material was present in the strata.

MINING TECHNIQUE

As mentioned briefly above, the mining technique will affect the drainage quality because it physically manipulates the rocks and the resultant rock-water interactions. If two areas are geologically similar it may be possible to affect the drainage quality by mining the coal by different methods; for example by either a shovel or dragline operation or by front-end loaders and haul trucks. Mining operations which primarily utilize a shovel or dragline for overburden removal, have spoil piles which are relatively uncompacted and have high infiltration rates. The infiltration rates will, of course, vary with the rock type, but the shovel or dragline mining technique will result in spoil material with the greatest infiltration rates.

The mine used in this study, located in east central Ohio, was mined by a shovel operation and had a backfill with an infiltration rate which varied from 0.76 cm (0.3") per hour to 3.8 cm (1.5") per hour.

Other mining techniques utilizing large trucks, front-end loaders, and earth scrapers will usually have lower infiltration rates due to increased compaction caused by the equipment traversing the area. In southwestern Pennsylvania, an area mined by the cut and fill method and moving the overburden with large trucks and bulldozers, had very low infiltration rates. The overburden material at the surface of the backfill was a gray shale, which after compaction by the constant traversing by equipment had an infiltration rate which was less than 0.15 cm (1/16 of an inch) per hour. These two examples probably represent the end members of the infiltration rates as affected by various mining techniques.

The rock types used as near surface material also affect the drainage quality and the mining method cannot disregard this factor. For this reason overburden segregation and manipulation are important considerations. In large shovel or dragline operations it is often difficult to segregate strata because this equipment tends to vertically mix the overburden. The resultant spoil is then a mixture of all rock types encountered. On the other hand, in areas where the overburden can be segregated, it is possible to layer the overburden in a manner which will have the least impact on ground water and the rocks can be manipulated so that discharges are of better quality. In areas of mixed overburden, where calcareous material is mixed with toxic, acid producing material, infiltrating water could encounter either rock type first. Assume that the infiltrating water initially contacts calcareous material and becomes alkaline. Next, it passes over toxic material, the alkalinity is depleted and the water becomes acidic and contains iron and sulfate. This water in turn, again comes in contact with calcareous rocks, the acid is neutralized, the pH rises and the iron precipitates on the rock surface. In time, as the same path is followed, the calcareous material can no longer neutralize the acid because an iron coating has deposited around the material and therefore, the resulting discharge is acid.

Contrast the above scenario with segregated overburden where the toxic material is buried and overlain by calcareous material. The water will reach carbonate equilibrium saturation and will have maximum alkalinity. This will contact the acid material and may have sufficient alkalinity to neutralize generated acidity. The toxic material is often segregated into a distinct zone but the alkaline material is placed on the entire mine surface so that infiltrating rainwater picks up alkalinity which infiltrates through through the entire mine. Although the concentration of alkalinity is fixed, this method allows the maximum load of alkalinity to be generated while the segregation of acid material may decrease the amount of water contacting the toxic material and decrease the acid load. Therefore, the two methods complement each other to reduce acid discharges.

RECLAMATION TECHNIQUE

Various reclamation techniques will affect the drainage quality because of resulting differences in infiltration rates, amounts of organic material, and evapo-transpiration rates. New federal regulations require that topsoil from the proposed mine site be stockpiled, seeded in order to preserve its characteristics and respread on the mine surface at the conclusion of mining (Federal Register, 1979). Because certain standards are stipulated in the regulations, the differences between reclamation techniques will be minimized. The type of vegetation planted will affect the evapo-transpiration rate and the amount of organic material which will build up on the soil horizon. The more dense the vegetation cover, usually the greater the evapo-transpiration rate. The greater this rate, the less water is available for infiltration and consequently, the drainage will be affected.

Also, different types of vegetation will result in different amounts of organic material available for decomposition and the accumulation of an organic mulch. As the organic mulch increases, the partial pressure of carbon dioxide will be raised. The infiltrating water becomes enriched in CO_2 and the solubility of any calcareous material in the backfill will be enhanced.

Prior to federal regulations, reclamation techniques were extremely varied. In many cases, trees were planted in spoil material and, even when trees survived, they did not produce sufficient organic matter to develop a spoil mulch. Topsoil was only rarely saved and respread on the surface. This resulted in varied infiltration rates and survival of planted material varied with the rock type, due to toxicity and water retention capabilities. However, with the advent of increased state and federal regulations, the variations in reclamation techniques and their affects on water quality are being minimized.

WEATHER AND CLIMATE

The weather and climate play an important role because the precipitation duration and intensity, weather patterns, and freeze-thaw actions all affect the infiltration rate. The precipitation duration and intensity have the greatest impact on run-off and infiltration rates. Very intense storm events, where the rainfall rate is greater than the infiltration rate, are accompanied by high runoff rates. Because the water cannot infiltrate into the material fast enough, much of the precipitation becomes runoff. This affects the drainage quality, because the water comes in contact primarily with surface material of the backfill and not with the material at depth. Conversely, a storm of low intensity would allow most of the water to infiltrate through the spoil material. The low intensity storms of long duration allow a migrating wetting front to develop after the soil moisture difficiency has been made up. However, if such storms are of short duration, there is usually insufficient water to overcome the soil moisture difficiency and no wetting front develops.

In addition to rainfall intensity and duration, the freeze-thaw actions play a significant role in the mine drainage quality. During freeze-thaw periods, water trapped in pore spaces of the rocks expands and contracts and with time, the rocks weaken and fracture. Within these fractures, more water accumulates and during repeated freeze-thaw actions, more fractures result. These fractures effectively increase the surface area of the rock and more pyrite or calcareous material is exposed. An example of this fracturing is best seen in certain types of shales in which weathering causes the shale layers to separate. As these shales or other rock types physically decompose, the infiltration rate decreases because the smaller particles are compacted.

Freeze-thaw actions are often sufficient to crack impermeable clay layers. Clay layers have been placed over toxic material in some mining situations to keep water from contacting toxic material. These clay layers are often only a few feet thick and are near the surface. Freeze-thaw actions in combination with alternating moist and dry conditions can cause cracks in the clay layer which will allow water to infiltrate through the clay layer and into the toxic material. This could have very severe impacts on drainage quality.

SECTION 4

LABORATORY METHODOLOGY AND RESULTS

The alkalinity source utilized in this study was provided by the Bedway Coal Company of Adena, Ohio and was a dolomitic, magnesium-rich limestone. Prior to any field trials, laboratory tests were conducted to determine the amount of alkalinity that could be generated by this material. The field tests involved spreading the less than 8 mesh reject agricultural limestone on the surface of an unreclaimed, twelve year old strip mine. In order to determine the application rates of limestone which would be most effective, laboratory tests were set up to determine the amount of alkalinity produced by various amounts of limestone which could then be related to application rates on a metric tons/hectare or tons/acre basis.

The dolomitic limestone should release alkalinity during rainfall events when the rainfall would wet the material and then, due to the porous nature of the backfill material, soak quickly into the ground.

Grab samples of the limestone to be used in the field tests were collected in October 1978 from a stockpile of limestone which had been previously shipped from the crushing plant in Zanesville, Ohio and used for a different field test. Although the composition of limestone from any quarry may vary slightly from one area of the quarry to another, testing this stockpiled material (realizing that it may have varied somewhat from the limestone which would actually be used in the study) could at least be used to give an approximation of the alkalinity that could be generated.

To determine the rate of alkalinity release from various weights of sample, the following set of tests was conducted. Five different weights of rocks which corresponded to different field application rates, were riffled from the grab sample and weighed. The weights used were 20, 50, 100, 250, and 350 grams which correspond to 5, 12.5, 25, 63, and 89 tons/acre respectively. Each weight of limestone represented a single sample and each sample was then subjected to simulated weathering tests (Caruccio, 1968; Geidel, 1979). Each sample was placed in an inert plastic box, purged with humidified air and periodically flushed. The sample was flushed by placing 100 mls of deionized water into the container, stirring the sample for 30 seconds to ensure that all weathering products which had accumulated during the weathering period of 3 to 4 days were in solution and then decanting the effluent. The effluent was analyzed for temperature, pH, alkalinity, acidity and specific conductance.

The results showed that the alkalinity, measured as mg/l as $CaCO_3$, increased with increasing sample size. This was later found to be due primarily to the short contact time of the limestone with deionized water. Because the reaction mechanisms for the generation of acid from pyrite (where the weathering products continue to accumulate with time) are different than those responsible for alkalinity generation (where the weathering products do not continue to accumulate with time) (Geidel, 1979), the release of alkalinity from this test was primarily in response to the solubility of the limestone during the 30 second flush.

Another factor which influenced these results was the amount of pore water left in the sample after it was decanted. In the samples with a small weight, nearly all of the water was decanted, where as, in the larger weight samples more water was retained in the pore spaces between the particles. The water retained in the boxes reacted with the limestone until equilibrium or saturation conditions were attained. However, when the 100 mls was added to this retained volume, the alkalinity in the pore water was diluted. Obviously, the greater the volume of water retained, the less diluted the alkalinity values became.

The combination of these two factors caused increased alkalinity with increased sample size and a non-linear relationship between alkalinity concentration and sample size. The results of the 30 second flushing interval were as follows: the 20 gram (5 ton/acre) sample produced between 22 and 44 mg/l alkalinity as $CaCO_3$; the 50 gram (12.5 tons/acre) sample produced between 27 and 50 mg/l alkalinity; the 100 gram (25 ton/acre) sample produced 32 to 38 mg/l alkalinity; the 250 gram (63 tons/acre) sample produced between 37 and 51 mg/l alkalinity; and the 350 gram (89 tons/acre) sample produced between 62 and 99 mg/l alkalinity. Due to the large range of values within each sample weight, equilibrium conditions were probably not attained. During one flushing cycle, (to determine what effect the contact time had on the alkalinity values) the water was left in contact with the 20 gram (5 ton/acre) sample for 2 minutes and then during another flushing for 5 minutes. These tests both resulted in alkalinity values of 110 mg/l. This value is probably very near equilibrium conditions which based on equilibrium constants, is 125 mg/l for pure limestone.

After this portion of the study had been completed, the economics of the study dictated that the total amount of limestone which could be used was 45 tons/acre. Based on the above results, which indicated that if the rainfall passed over the sample in 30 seconds, more than 89 tons/acre would be required to achieve maximum alkalinity, coupled with the economic restraints, the maximum amount of limestone available (45 tons/acre) was scheduled for spreading over the entire area. After the limestone was delivered to the site and during the field application, grab samples of the limestone material were collected. The material was analyzed using x-ray diffraction to determine its composition and was determined to be a mixture of dolomite, high magnesium limestone and quartz. Simulated weathering studies were again conducted but this time the actual application rates which were applied at the site were transposed to various weights to be used for the study. The samples were leached with both deionized water and simulated acid rain. The acid rain was similar in composition to that collected at the site during rainstorm events. The rates tested were 37, 50, and 70 ton/acre. Although it has been suggested that the acid rain will increase the solubility of the limestone and release additional alkalinity, the results indicated that the use of acid rain did not increase the amount of alkalinity produced. In two of the samples, the 37 and 70 ton/acre samples, the acid rain produced alkalinity values the same as those produced by the deionized water. In the 50 ton/acre sample, the alkalinity produced by the sample leached with acid rain was actually slightly less than the alkalinity produced by the sample leached with deionized water.

The six samples (37, 50 and 70 ton/acre flushed with water and 37, 50 and 70 ton/acre flushed with acid rain) were leached once every 3 to 4 days and the water or simulated acid rain was allowed to stay in contact with the material for one minute. However, even leaching the sample for one minute did not result in equilibrium conditions. The 70 ton/acre samples leached with either water or acid rain generated an average of 64 mg/l alkalinity, the 50 ton/acre sample leached with water generated an average of 54 mg/l alkalinity, the 50 ton/acre sample leached with acid rain generated an average of 49 mg/l alkalinity and the 37 ton/acre samples leached with either leachate generated an average of 49 mg/l alkalinity. Originally, it was anticipated that rainfall at the site would contact the limestone and soak into the ground rapidly. However, at an application rate of 45 tons/acre the depth of the limestone would be approximately 0.63 cm (0.25 inches) deep. For the water to migrate through this material in one minute, the infiltration rate would have to be 37.8 cm/hr. (15 in./hr.). Percolation tests at the site, although done at approximately one foot depths, indicated infiltration rates varied but did not exceed 3 cm (1.5 in.)/hr. Based on these figures, it would take approximately 10 minutes for water to migrate through the limestone layer. To be on the conservative side, if this figure were halved, the rainwater would be in contact with the limestone for five minutes. At these projected infiltration and flow through times it is anticipated that the water passing through the limestone layers will be at near equilibrium and saturated conditions when the water enters the backfill.

SECTION 5

FIELD METHODOLOGY

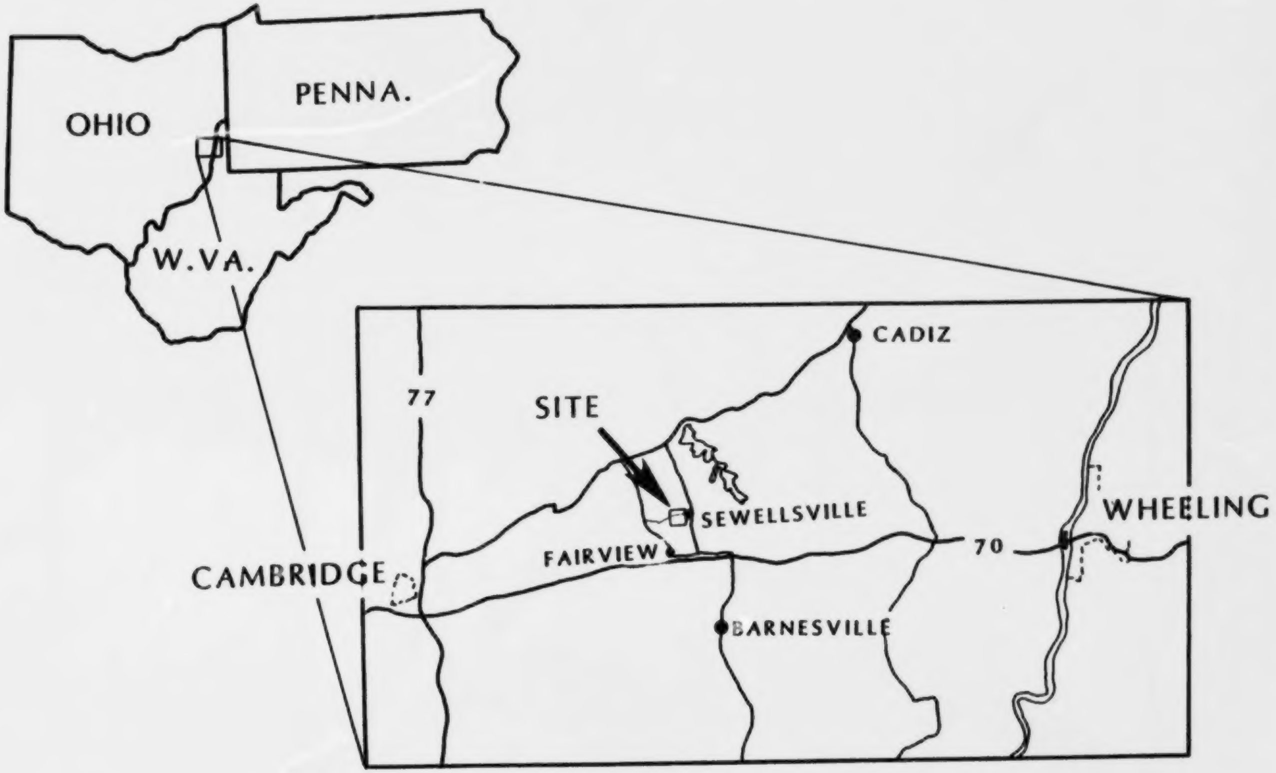
AREA OF STUDY AND GENERAL GEOLOGY

The site chosen for this study is a 60 hectare (150 acre) drainage basin in east central Ohio which is shown in Figure 1. The area which is approximately 30 miles west of Wheeling, West Virginia, on the border between Belmont County and Guernsey County, Ohio, is a portion of a 800 hectare (2000 acre) area which was strip mined between 1968 and 1970 by a large shovel operation. During this period, neither state nor federal regulations had been promulgated to require that the area be returned to original contour or that the topsoil be retained and replaced on the surface of the spoil at the completion of mining. As a result, this area is bounded on three sides by a highwall, the existing topography is different than the premining surface configuration and there is no soil cover on the surface of the backfill.

The coal seams mined on this 800 hectare site were the Pittsburgh (or No. 8) seam and the Sewickly (or No. 9) seam. The No. 9 seam, however, was present on only a few selected hilltops and was not present within the smaller study basin.

The Pittsburgh seam is the lowest member of the Monongahela formation of Pennsylvania age. A generalized stratigraphic section of this portion of Belmont county is shown in Figure 2 (Berryhill, 1963). In the eastern portion of Belmont County, the Pittsburgh seam is overlain by the Redstone limestone, however, in the west-central portion of the county, the Redstone member grades into the deltaic Pittsburgh sandstone. Berryhill described the sandstone member as representing two stages of clastic deposition. The lower portion of the unit, which is usually only a few feet thick, consists primarily of a fine grained sandstone, siltstone, and mudstone. The upper portion, which constitutes most of the unit, is a massive channel sandstone of variable thickness, up to 50 to 60 feet thick in this drainage basin. The sandstone is irregularly bedded and crossbedded, medium to coarse grained, micaceous, poorly sorted and has an undulatory base. Berryhill also noted the occurrence of coalified and pyritized log fragments in the unit, and thin stringers of coal near the base. Additionally, he observed that the pyrite was locally abundant as nodules.

The coal mining operation at this site removed a maximum of approximately 45 feet of overburden to expose and mine the Pittsburgh (No. 8) coal. Most of the overburden was composed of the Pittsburgh sandstone which contains many pyrite nodules. Nodules have been found at the site


OHIO
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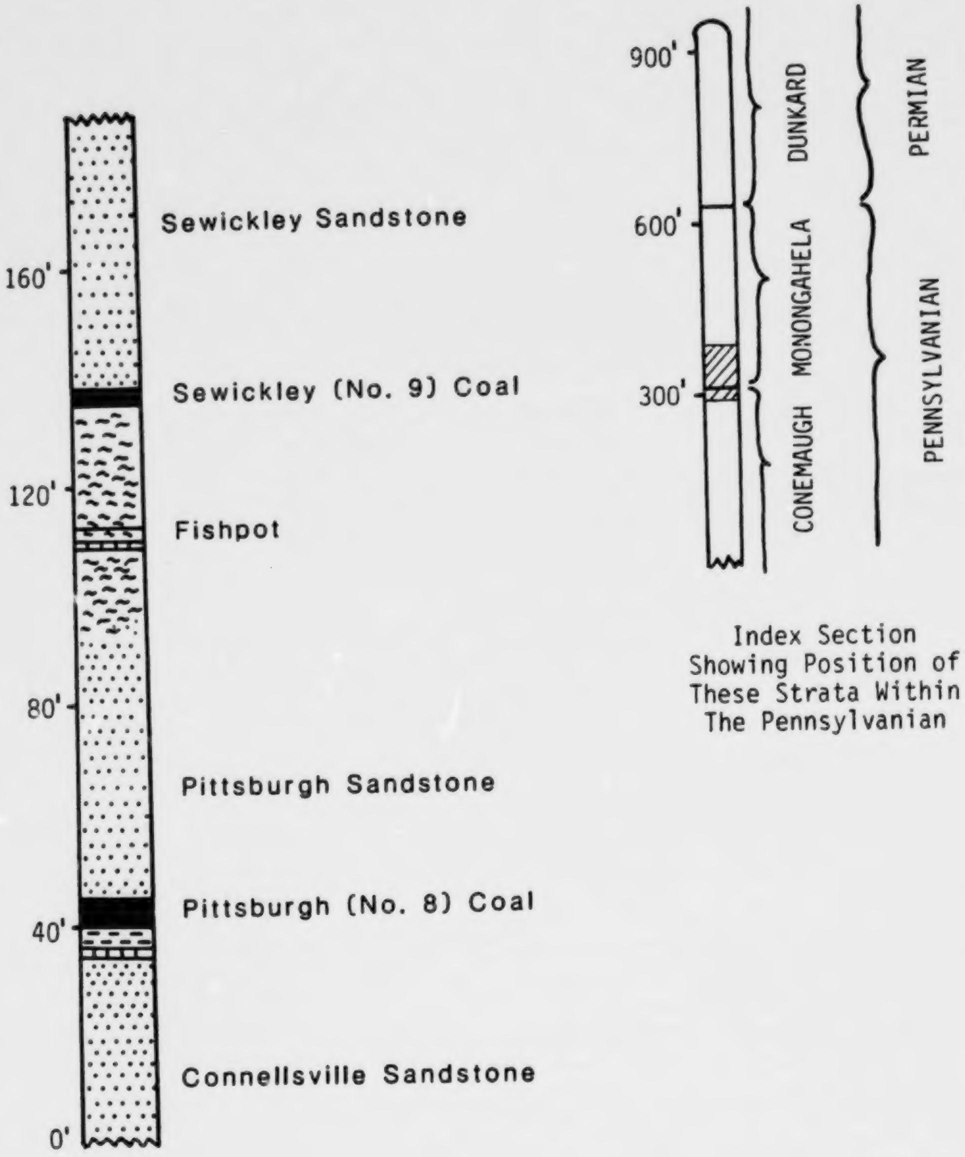
SEWELLSVILLE
FAIRVIEW
CAMBRIDGE
BARNESVILLE
70
WHEELING

Figure 1. Location of Study Area

TYPING GUIDE SHEET


Sewickley Sandstone
160'
Sewickley (No. 9) Coal
120'
Fishpot
80'
Pittsburgh Sandstone
Pittsburgh (No. 8) Coal
40'
Connellsville Sandstone
0'
900'
600'
300'
DUNKARD
MONONGAHELA
CONEMAUGH
PERMIAN
PENNSYLVANIAN

Index Section
Showing Position of
These Strata Within
The Pennsylvanian

Figure 2. Generalized Columnar Section of the Rocks in the Vicinity of the Study Area

and vary in size from one to ten centimeters in diameter.

Due to the nature of the shovel mining operation, the resulting surface material is relatively uncompacted and varies in size from boulders to fine grained sand. The permeable nature of the surface material allows rapid infiltration of rainfall and the exchange of oxygen between the air and near surface environments. As a result of these conditions, the pyrite within the sandstone oxidizes readily and releases iron, sulfate and acidity. The infiltrating rain water emerges from the spoil as numerous seeps, the water quality of which vary from alkaline to severely acidic. These seeps either drain directly into or coalesce and drain into the streams in the area causing the quality of the streams to become severely degraded.

At the conclusion of the mining operation, attempts were made to revegetate the mine surface. At the beginning of this project, 10 years after attempted vegetation, some areas had good stands of crown vetch while other areas had no cover. Although no detailed studies were conducted to ascertain the cause of the lack of growth in certain areas, it is hypothesized through field observation and the increase in vegetation throughout the time frame of this study, that the lack of vegetation was due primarily to the toxic nature of the surface material and partially to lack of moisture. In certain areas, large blocks of sandstone, two meters in diameter, lie within 2 cm of the surface. In these cases, not enough moisture can be retained to sustain plant growth.

SITE SELECTION

The site chosen for this study is a subbasin within the Skull Fork drainage basin and is located on the Fairview, Ohio 7½ minute quadrangle, 1.5 kilometers west of Sewellsville, Ohio. The study basin contains approximately 60 hectares (150 acres), two-thirds of which were affected by strip mining operations between 1968 and 1970. The area is outlined on the northwestern portion of the general road map of the area and is shown in Figure 3.

The present topography of the site is different than the one shown to exist on the topographic map which was made in 1961 prior to mining. The western ridge has been displaced 50 to 100 m to the east and the eastern ridge has been separated into two parallel ridges divided by a shallow swale that contains several ponds. The No. 8 coal was mined at an elevation of approximately 1180 feet A.S.L. Consequently, all material now found above this elevation is identified as disturbed spoil material which has been placed on the seat earth. Disturbed areas below this elevation are zones where spoil material was cast down slope covering the original terrain.

The drainage network has also been modifed by the mining operation. The two valleys forming the headlands of the basin were partially filled and the existing stream channel truncated. Farther downstream, two dams were constructed across the channel and two ponds formed behind the dams. The water emanating from the upper pond was at one time treated with

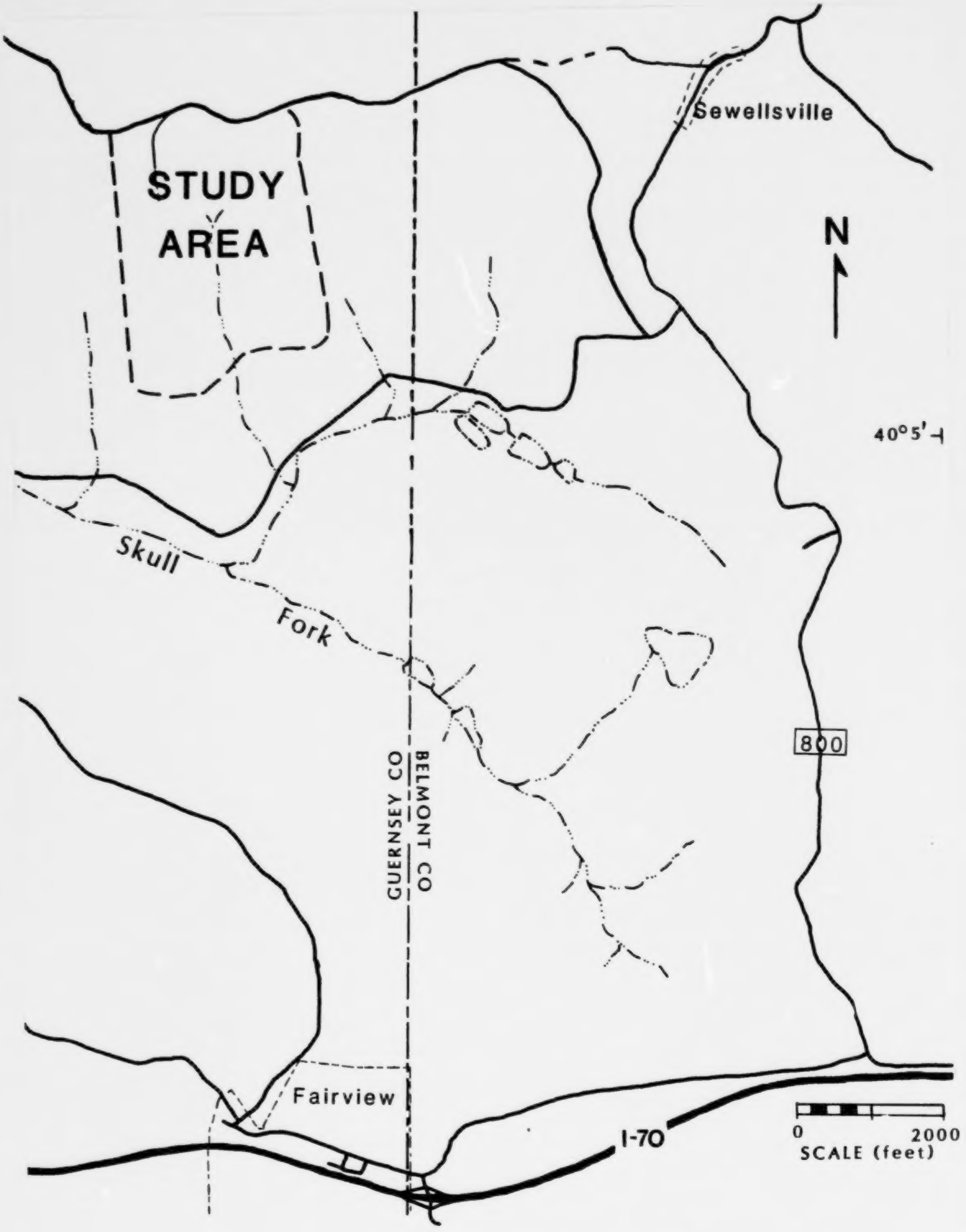

STUDY AREA
Sewellsville
N
40°5'
Skull Fork
800
GUERNSEY CO
BELMONT CO
Fairview
I-70
0
2000
SCALE (feet)

Figure 3. Location of Study Area with Respect to General Road Map

sodium hydroxide (NaOH) and the second dam formed a settling pond to collect the resulting precipitates. Downstream from the second dam, the stream bed appears to follow the pre-mining channel.

BASIN DESIGNATION

Criteria for separation

From a preliminary survey, seven subbasins were delineated, based on topographic expressions and surface water divides. Additional refinements of the drainage basin of study were based on water quality data obtained from a detailed geochemical survey of seeps and springs occurring within the drainage basin and related to headwater sources.

Geochemical survey--

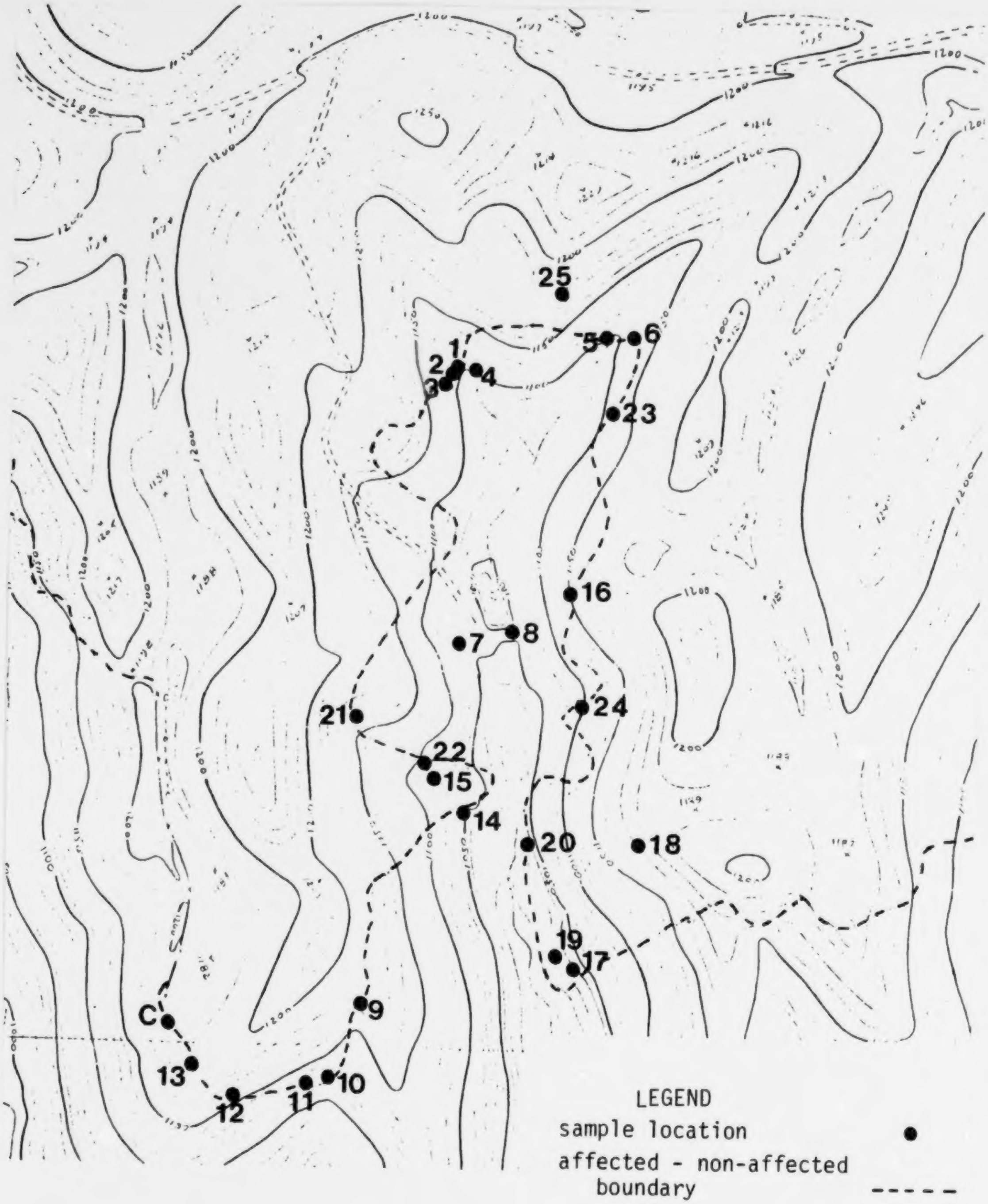
The primary basis used for subbasin designation was the data collected from a detailed geochemical survey of seeps, springs, and ponds within the major drainage basin. During October 1978, April 1979, and June 1979, field investigations resulted in locating and characterizing ten ponds, one spring and over thirty seeps. Those seeps with significant flows and which were selected for routine monitoring are shown on the post mining topographic map in Figure 4.

The ponds are located in the extreme eastern and western portions of the study area and at the approximate elevation of the top of the seat earth. This suggests that the impervious nature of the seat earth allows water from seepage, runoff or rainfall to accumulate in these locations. During periods of high precipitation, these ponds overflow and become connected by a series of streams that flow in a southerly direction. During dry periods, though, the water level of the pond decreases and the streams do not flow. However, at point C, located at the southwestern end of the basin (Figure 4), a stream draining the ponds in this area has been observed to be perennial.

In Figure 4, an affected/non-affected boundary is outlined. For the purpose of this discussion, an affected area is considered to be any area which was mined or disturbed during mining, or any area where overburden material was cast down slope, covered the existing vegetation and altered the pre-mining topography. A non-affected area is land that was not impacted by the mining operation.

The seeps generally occurred at the boundary between the affected and the non-affected area. Water infiltrating through the highly permeable sandstone spoil material may move down slope along the contact of the pre-mining ground surface and the cast material, and emerge at the affected/non-affected boundary as a seep.

All seeps, ponds and springs were located and identified. During the field survey, measurements of pH, specific conductance and temperature were made whenever possible and samples of the drainages were collected and analyzed in the laboratory for acidity, alkalinity, conductivity,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1200
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1150
1100
LEGEND
sample location ●
affected - non-affected boundary - - - - -

Figure 4. Topographic Map of Drainage Basin Showing Location of Seeps

calcium, magnesium, and sulfate. Seeps and springs were designated with numbers while ponds were designated with letters. After a preliminary geochemical survey, twenty-five seeps and one stream were selected for routine weekly monitoring. These were chosen to be representative of all parts of the basin and would provide the basis of comparison of one subbasin to another. The only seeps which were identified but not used were located in the southwestern portion of the drainage basin. There were approximately ten seeps of similar quality and the four seeps with the greatest flow were selected as being representative of this basin.

The sample locations at the springs and seeps were then marked with brightly colored stakes which were driven into the ground, numbered according to sample point and covered with plastic. Additional markings were placed on nearby trees and rocks to help locate the seep.

The preliminary geochemical survey included laboratory analyses of samples as well as field measurements. All subsequent weekly sample collection had field temperature measurements, but the remainder of the analyses were conducted in the laboratory. All samples were analyzed for pH, acidity, alkalinity, specific conductance and once a month they were analyzed for sulfate. These parameters could be readily related to the chemistry of the material and are indicative of particular geochemical reactions with regard to pyrite oxidation and carbonate dissolution. The reasons for choosing the specific parameters are outlined below.

pH--The pH reflects the degree of acidity or alkalinity that could be expected from the sample. In general terms, the character of the sample could be quickly determined and related to the geochemical of the strata. The pH of all alkaline samples was measured immediately after collection using a portable Photovolt pH meter. Acid samples were measured upon arrival in the laboratory. Prior to measurement, the meter and electrode were calibrated using the appropriate buffers.

Conductivity--The electrical properties of the solution reflect its ionic strength. As such, the conductivity and the total dissolved solids content of the water sample are related and provide an indication of the chemical activity that has taken place within the spoil along the path of ground water movement. Conductivities of samples were measured using a Universal Interloc conductivity meter which was calibrated against a conductivity standard solution.

Acidity--Drainage acidity develops principally from the hydrolysis of the oxidation products of reactive pyrite. The pyrite oxidizes to produce a ferrous sulfate compound which is soluble in water and hydrolizes to produce acidity and sulfate. In the absence of neutralization, the measure of the acidity of water flowing from a seep is a good estimate of the amount of reactive pyrite that could be expected to be found in that particular zone. If some degree of neutralization takes place then the acidity and alkalinity concentrations are reviewed in conjunction with sulfate concentrations which fingerprint the pyrite oxidation reactions.

Total acidities were determined in a laboratory after boiling the sample for two minutes. This insured the complete oxidation and hydrolysis of the iron compounds and expelled the carbonic acid acidity. The sample was then titrated with a 0.02N sodium hydroxide solution to a pH 8.3 endpoint which was potentiometrically determined (Standard Methods, 1971).

Alkalinity--The alkalinity of water in this geochemical regime is a function of the carbonate and bicarbonate species present in the sample. Contribution to alkalinity by hydroxides is rare in this area. Carbonate and bicarbonate alkalinity come from the carbonic acid dissolution of basic materials in the strata (principally calcium, magnesium carbonate).

Alkalinity values were determined by titrating an aliquot of sample with a 0.02N sulfuric acid solution to an endpoint of pH 4.5 which was potentiometrically determined (Standard Methods, 1971).

Sulfate--Sulfate concentrations were analyzed by both the Thorin titration method outlined in Rainwater and Thatcher, 1960 and by the Technicon Industrial Auto Analyzer II. To preclude cation interferences, the samples were passed through cation exchange columns before performing analyses.

As noted previously, the decomposition of pyrite produces sulfate, in addition to iron and acidity. On the assumption that the overburden did not initially contain abundant amounts of either gypsum or anhydrite (Berryhill, 1963; Wright, 1953), it would be readily assumed that the primary source of sulfate is the decomposition of reactive pyrite. As such, sulfate contents are an excellent measure of the degree of reactive pyrite present in the material.

When the results of all the analyses were compared to the location of each sample point, a strong correlation existed between the seep quality and the location of the seep. The seeps in the southwestern part of the basin (#10, 11, 12, and 13) contained high concentrations of acidity (2000-3000 mg/l) and sulfate while those in the southeastern section (#17, 18 and 19) were low acid (50-200 mg/l) or alkaline (#20). A pattern emerged for all seeps within the drainage basin and the seeps were classified as either high acid (1500-3000 mg/l), medium acid (400-1000 mg/l) or low acid (50-200 mg/l). Similarities of drainage characteristics for samples in close proximity were used to further subdivide the larger basin into a series of small basins.

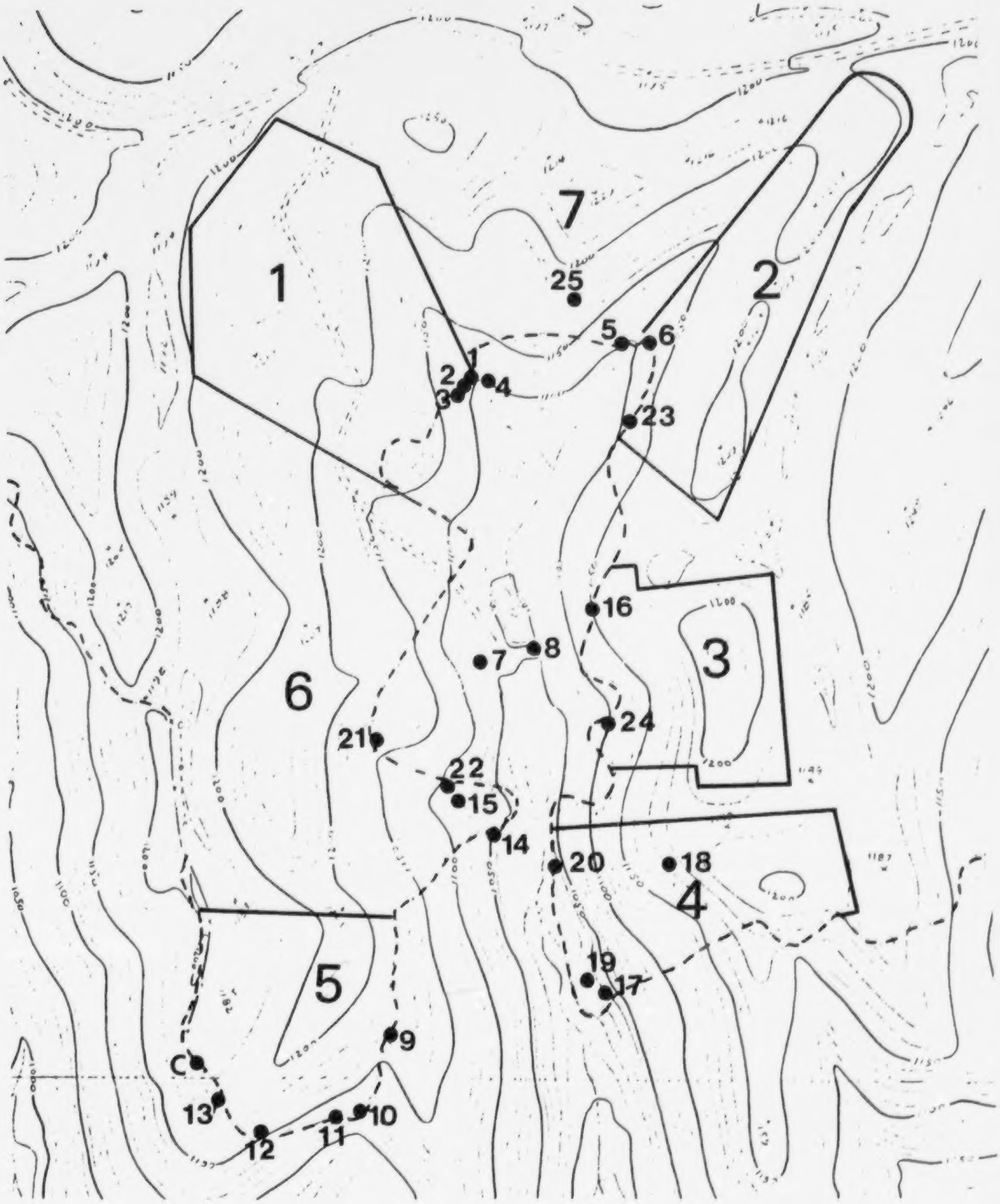
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Figure 5. Map of Drainage Basin Showing Sub-Basin Designations

Topographic Separation--

The second criterion for basin designation was the topographic expression of surface water divides. As seen in Figure 4, the major stream which flows in a southerly direction is bounded on either side by steep slopes (15^o - 26^o). The ridges of these slopes constitute the major east-west surface water divides and the undulations along the ridges form the minor north-south surface water divides. The boundary of each subbasin was delineated by these topographic divides following the initial boundary designation based on geochemical data. It was anticipated that the surface water divide would approximate the ground water divide, but due to the uncertainty of the hydrology, the area of the subbasins was extended to include the portions adjacent to the divide. Based on the results of the geochemical survey, coupled with the topographic expressions, seven basins were designated (Figure 5).

Description of Basins

Of the seven basins shown in Figure 5, five basins, numbered 1 through 5, were scheduled for limestone treatment. Those areas numbered 6 and 7 remained untreated and served as controls.

Basin #1 is located in the northwestern portion of the drainage basin and is identified as the source of seeps #2 and #3 and contributes to some of the flow from #1. Seep #2 is highly acidic with a constant and continuous flow. Seep #3 has a sporadic flow and was characterized as moderately acidic. Seep #1 emanates from a stream bed which divides basin #1 and #7. The stream bed is dry until the stream intersects the affected/ non-affected boundary. The area of the basin was measured to be 7.63 hectares (18.86 acres).

Basin #2 is located in the north eastern part of the basin and is the recharge site for seeps #6 and #23 both of which are moderately acid seeps. The area of the basin was measured to be 5.21 hectares (12.88 acres).

Basin #3 is on the eastern side of the drainage basin, south of Basin #2 and separated from Basin #2 by an untreated area. This is the smallest basin with an area of 4.16 hectares (10.27 acres) and is drained by seeps #16 and #24 which are high acid.

Basin #4 is located in the southeastern portion of the drainage basin and its southern boundary constitutes the southern limit of mining on the eastern side of the basin. Three low acid seeps (#17, 18, and 19) and one alkaline seep (#20), occur on this area. Seep #18 emanates from the coal outcrop at an approximate elevation of 1180 feet, seeps #17 and 19 appear at the south side of the base of the hill and #20 has a defined stream path flowing down the north side of the slope. The area of the basin is 4.5 hectares (11.13 acres).

Basin #5 is in the south western-most part of the affected basin and reflects the southern limit of mining on the western side of the drainage basin. The area is the source of seeps #10, 11, 12 and 13 which occur in that order from east to west and are very high acid (2000-3000 mgs/l). Seep #9 has an intermittent flow and is of limited use. The area of the basin is 4.94 hectares (12.2 acres).

Basin #6 is situated between Basin #1 and Basin #5 and is the source of seeps #7, 14, 15, 21 and 22. Seeps #21 and 22 are medium acid and #7, 14 and 15 are alkaline. This is a control basin and no limestone was spread in this area.

Subbasin #7 lies in the northern part of the drainage basin between Basins #1 and #2. This is a control, untreated basin and is characterized by seeps #1 and #4 on the western side and seeps #5 and #25 on the eastern side, all of which are medium acid seeps.

Surveying Methodology

Following the preliminary designation of the various basins on the topographic map, the boundaries were identified in the field and surveyed using a Brunton compass mounted on a tripod assembly. Any adjustments of the boundaries which had to be made in the field, based on physical conditions of the site, were made at this time and the modification shown on the map. The boundaries of the basins were marked with fluorescent orange or yellow surveying tape. By alternating the colors between basins, the boundaries of the basins could be easily identified and recognized during the limestone application. In areas where the surface lacked vegetation, the surveying tape was attached to metal stakes which were driven into the ground. However, in vegetated areas, the tape was most visible when it was attached to the tall vegetation.

LIMESTONE TREATMENT

Application Principles

As shown in the beginning of this report the primary objective was to determine the natural limit of carbonate-bicarbonate alkalinity that can be generated under field conditions. By determining the acidity of the system prior to the limestone application, the degree of amelioration of the acid system by the limestone can be established. Within this drainage basin there are seeps with acidity concentrations that vary from low to very high. By monitoring these seeps after the limestone application, it was possible to determine the decreases in acidity concentrations and the level of acidity affected by the application.

In addition, through the laboratory studies (results of which are discussed in Section 4) the optimum application rate of carbonate material was established. Simulated weathering tests on various tonnage rates of limestones were conducted in the laboratory to determine the optimum application rate. Due to the solubility constraints of the limestone system, the saturation of calcium carbonate in water is quickly achieved. Rainfall, even though it is slightly acidic in this area, will become saturated with HCO_3^- soon after it comes in contact with the limestone. There is an asymptotic relationship between the amount of alkalinity generated and the weight (or rate of application) of the limestone. It was found that at a rate of 11 metric tons/hectare (5 tons/acre) very little alkalinity was generated when it was leached for a short period of time (similar to a rainfall event). Increasing amounts of alkalinity were generated with increasing tonnage rates up to approximately 90 metric tons/ha (40 tons/acre). Tonnage rates greater than this generated only minor amounts of additional alkalinity. The 90 metric ton/ha (40 tons/acre) corresponds to a field application dosage that blanketed the entire backfilled surface with a thin (¼") layer of limestone.

This study evaluated the effects of applying approximately 90 metric tons/ha (40 tons/acre) coverage up to approximately 150 metric tons/ha (70 tons/ acre) coverage. To evaluate the limestone application under optimum conditions, 90 metric tons/ha (40 ton/acre) was the lowest application rate used because, with the measured percolation rates of 0.83 cm (0.3 in/hr) to 3.25 cm/hr (1.25 in/hr.), saturation conditions under normal rainfall events should be achieved with this application rate. Additionally, this value was chosen because the acidity of the seeps was such that the maximum amount of alkalinity (based on the solubility of calcium carbonate) would be required to decrease the acidity in the seeps.

The third objective of the limestone application was to evaluate the alkaline and acid concentrations as a function of rainfall and infiltration. Once the effect of the limestone became apparent in the seeps, it was possible to determine, with the use of a recording rain gage and the results of percolation tests, the effect that rainfall intensity and duration had on the quality of the seeps.

Method of Spreading

Because of the acid producing nature of the backfill surface material, it was decided that a surface application of limestone would produce better results than limestone which was turned-in and mixed with the near surface material. The near surface material contained significant amounts of pyritic material and during the oxidation of pyrite, iron is placed into solution. When the iron rich solution comes in contact with alkaline material, the increase in pH will cause iron to precipitate and armor the limestone. Spreading the limestone on the surface minimizes its contact with the iron rich material and the limestone will produce alkalinity for longer periods of time.

Surface spreading also produces a more uniform and more controlled application rate. Broadcasting of the material can be controlled to a greater extent than attempts to mix a specified amount into the surface material. The surface material is variable in size; from large boulders to sand grains. The presence of these boulders precludes any attempt of using harrow disks or machinery to uniformly mix the limestone with the near surface material.

Also because of the steep slopes in the affected area, surface spreading would provide more complete coverage of the area. The spreader truck can easily maneuver on the steep slopes and can broadcast over cliffs to give as complete coverage as possible.

Methodology

The material used in this study was rejected agricultural dolomitic limestone. The rejection was based on its non-uniform particle size which varied from dust to 8 mesh. The Bedway Coal Company of Adena, Ohio provided the material and transportation from the plant in Zanesville, Ohio.

The limestone was spread by Mr. Robert Harris of Harris and Son Contracting by a 4 wheel drive spreader truck which was capable of carrying approximately 11,000 kg (12 tons) of limestone. The spreader assembly broadcasted the limestone approximately 5 to 8 meters to either side of the truck and by traversing the area applied a rather uniform coverage.

Table 1 shows the approximate number of tons spread per subbasin and the application rate. A total of 3055 tons of limestone was delivered to the site and Mr. Harris provided us with a basin by basin total tonnage spread. The site was field checked during and after the spreading phase. Some areas where the gulleys on the slopes were too deep or where there were too many large trees, the truck was unable to apply the limestone. These areas, however, constituted only a small portion of the basins.

TABLE 1. LIMESTONE APPLICATION RATES IN DESIGNATED BASINS APPLIED BETWEEN JUNE 13 AND JUNE 26, 1979

Basin	Area of Basin	Number of Tons Applied	Application Rate
#1	7.63 ha. (18.86 acres)	742 m. tons* (817 tons)	97 m. tons/ha. (43 tons/acre)
#2	5.21 ha. (12.88 acres)	780 m. tons (860 tons)	150 m. tons/ha. (67 tons/acre)
#3	4.16 ha. (10.27 acres)	332 m. tons (366 tons)	80 m. tons/ha. (36 tons/acre)
#4	4.50 ha. (11.13 acres)	506 m. tons (558 tons)	112 m. tons/ha. (50 tons/acre)
#5	4.94 ha. (12.2 acres)	411 m. tons (454 tons)	83 m. tons/ha. (37 tons/acre)

Total limestone applied in area = 3055 tons

*metric tons

SPIKING

Objectives

The objectives of the spiking or tracer application phase of the study were three fold. First, the use of tracers delineated the effectiveness of various rates of limestone application. By spiking the area during the same day that the limestone was applied and by monitoring the seeps for the presence or absence of the spikes, the water quality characteristics from each basin were related to the limestone application rates. Spiking was also used to determine whether a change in the water quality from a seep was directly related to the limestone application.

Secondly, the tracers were used to delineate the flow paths of the water infiltrating through the overburden and to determine if there was any inter-basin flow. The spikes were applied according to a pattern in order to determine the basin or origin of a spike when it was measured in a seep.

The third objective was to determine the travel time of the spike through the spoil. By applying the spikes at different elevations above the seeps and noting when the spikes first appeared in the drainage, the length of time required for the water to migrate through the overburden was determined. The travel time of the various spikes also provided additional information on the flow paths of the migrating water.

Criteria for Spike Selection

In order that the spikes selected fulfill the stated objectives: the material selected as tracers had to be absent from the section and rainfall; measured easily and quickly because of the number of samples tested each week; not excessively expensive; and safe when they emanated from the seeps and flowed into the drainage system. A variety of substances, including fluorescent dyes, unstable (radioactive) isotopes, rare cations and anions were considered as possible spiking material. Fluorescent dyes were not used because they can be degraded by acid conditions which are prevalent throughout the drainage basin and many seeps in the basin have a characteristic iron red color which would mask dyes. The use of unstable isotopes was not satisfactory because it would have to be authorized through the appropriate federal agency and measurements are very time-consuming. Rare cations were very expensive and their mobilization is often directly related to the pH of the system. An increase in pH, as would be expected after the limestone application, would decrease the mobilization of these ions. For these reasons, the spikes best suited for our purposes were anions, specifically iodide, bromide, and fluoride. All three were absent in the system and were easily measured with selective ion electrodes. The sensitivity of these probes permits the use of minimal quantities of chemicals and measurements of dilute concentrations of ions in the seeps. The use of minimal quantities also assures us that even under low flow conditions of the drainage basin, the tracer would not be present in the stream in concentrations considered harmful.

Method of Application

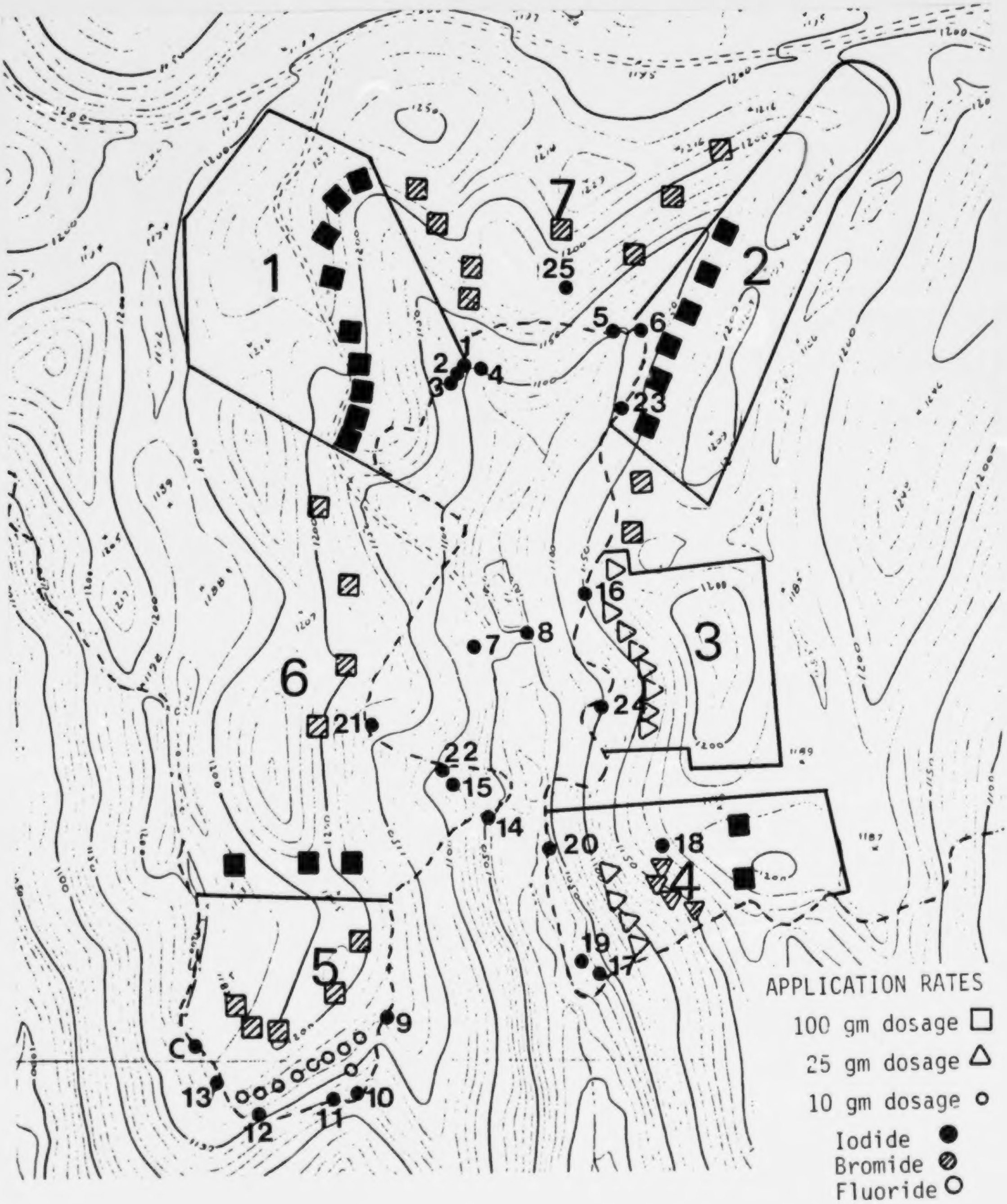
Each basin was assigned a specific tracer. The tracers were selected so that the seeps draining each basin exhibited a particular tracer and if inter-basin flow occurred, this was picked up by the presence of a different spike. For this reason, adjacent subbasins were treated with different spikes. In two basins which were relatively isolated from the other basins, all three tracers were applied, each at a different elevation, to better delineate the flow paths and travel time of the infiltrating water.

The chemicals chosen for the spikes were potassium iodide (KI), sodium bromide (NaBr), and potassium bromide (KBr), and ammonium fluoride (NH_4F). Based on the area of each basin and the average infiltration the amount of spike required to produce a detectable concentration in the seeps was calculated and applied.

The tracers were applied during June, 1979, at the dosage rates given in Table 2. As of October, 1979, tracers had been found in 8 seeps. In order to ensure that the concentrations of tracer would be greater than the detection limits, the entire area had tracers reapplied prior to the winter snows. The reapplication insured that during the spring thaw, when there is an increase in the amount of water available for infiltration, the tracers were not too diluted to preclude measurement. This second application rate is also given in Table 2. Figure 6 shows the location of application of the spike within each basin during June and Figure 7 shows the October application sites. The squares indicate that the spike was applied in 100 gram doses, the diamond in 50 gram doses, the triangles in 25 gram doses and the circles in 10 gram doses.

TABLE 2. DOSAGE RATES OF TRACERS APPLIED IN THE SUBBASINS

Basin	Spike	Dosage Rate Applied In June, 1979	Dosage Rate Applied In October, 1979
#1	Potassium Iodide	900 gms. I^-	500 gms. I^-
#2	Potassium Iodide	600 gms. I^-	600 gms. I^-
Between #2 and #3	Sodium Bromide	200 gms. Br^-	200 gms. Br^-
#3	Ammonium Fluoride	100 gms. F^-	200 gms. F^-
#4	Ammonium Fluoride	50 gms. F^-	100 gms. F^-
	Sodium Bromide	100 gms. Br^-	200 gms. Br^-
	Potassium Iodide	200 gms. I^-	200 gms. I^-
#5	Sodium Bromide	100 gms. Br^-	300 gms. Br^-
	Ammonium Fluoride	50 gms. F^-	200 gms. F^-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APPLICATION RATES
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Bromide ▨
Fluoride ○

Figure 6. June, 1979 Tracer Application Sites and Dosage Rates

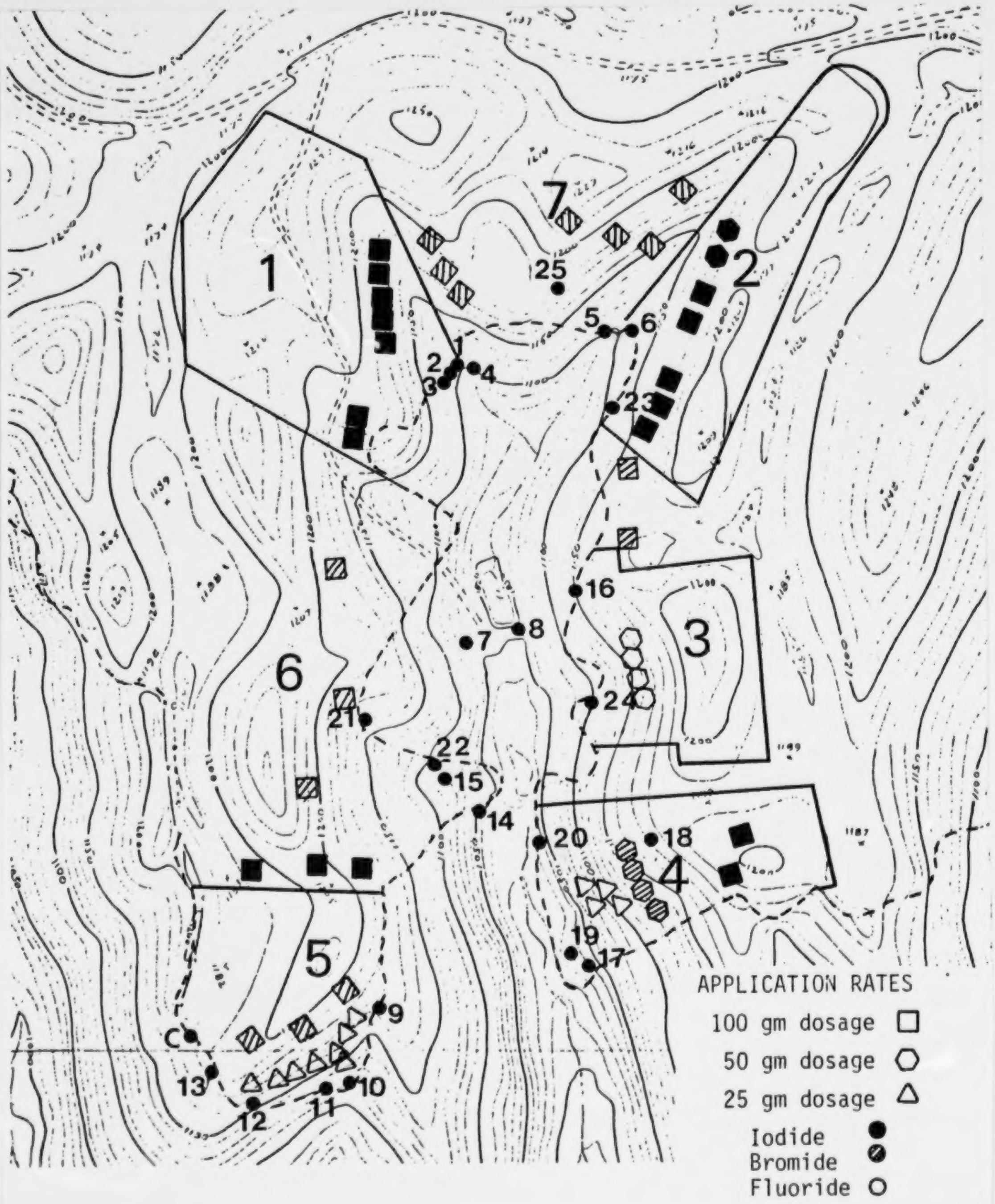
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Figure 7. October, 1979 Tracer Application Sites and Dosage Rates

TABLE 2. DOSAGE RATES OF TRACERS APPLIED IN THE SUBBASINS (cont.)

Basin	Spike	Dosage Rate Applied In June, 1979	Dosage Rate Applied In October, 1979
#6	Sodium Bromide	400 gms. Br^-	300 gms. Br^-
	Potassium Iodide	300 gms. I^-	300 gms. I^-
#7	Sodium Bromide	800 gms. Br^-	700 gms. Br^-

As a safety measure, the total concentration of tracer available to the system was also calculated. Assuming that all of the spike was flushed through the system at once and flowed into the stream at one moment (which is impossible due to the method of application) and assuming an average flow of 140,000 liters per day (Kalb, 1980), the following concentrations would be present at a point approximately 100 meters upstream from the confluence of the stream draining the study basin and Skull Fork: Iodide, 12.8 mg/l; Bromide, 14.3 mg/l; and Fluoride, 1.4 mg/l. As the stream flowed into Skull Fork, the concentrations would decrease by at least one order of magnitude. It is extremely unlikely that all of these chemicals could enter the stream at one time and our analyses of Seep #8 (a stream sampling point) showed extremely low concentrations of the tracers.

The tracer chemicals were weighed out in 100 gram quantities of the anion and placed in 125 ml polypropylene bottles. Approximately 100 milliliters of distilled water were added to each bottle and the chemical dissolved. At the locations indicated in Figures 5 and 6, a trough about 20 cm (8 inches) deep and 20 cm (8 inches) long, was dug with a shovel. The tracer was then poured into this trough and covered with the spoil material.

The tracer was placed below the surface of the spoil for several reasons. First, the tracers were intended to measure the flow paths of ground water and not surface water runoff. During most rainfall events, there is insignificant runoff due to the highly permeable nature of the material, however, in the event of an intense storm, placing the tracer beneath the surface layer would preclude the measurement of the tracer in the seeps in response to runoff. Secondly, any standing water or salt crusts on the surface might be consumed by the wildlife and prove harmful. Thirdly, because the ground was dry during the emplacement of the tracers, the tracer could migrate only after water had infiltrated through the limestone and spoil material to a depth sufficient to intercept the tracer. Therefore, in order for the tracer to migrate and be discharged, additional water from infiltration through the surface material must be available.

RAINFALL

In June 1979, a Weather Measure recording rain gage was installed on the roof of Mr. Showwalter's shed in Sewellsville, Ohio, approximately 1.5

kilometers from the site. We had been warned of vandalism in the area and felt that it would be protected from hunters in that location. The recording gage provided a measurement of the total rainfall and rainfall intensity.

On the site, in Basin #1, a non-recording plastic rain gage was installed. This rain gage not only provided an uncontaminated sample of rain water for chemical analysis, but also provided a total rainfall measurement for each week which could be compared to the rainfall measured at the recording rain gage station. The total rainfall at the two sites were very similar. During high intensity, short duration storms (i.e., summer thunderstorms) there was a slight variation between total rainfall at the two sites, but the variation was usually less than one-half centimeter.

The chemical quality of the rainwater can be characterized as mildly acidic with a low ionic strength. During June 1979, samples were collected and analyzed immediately after each storm event, subsequently samples were collected and analyzed once a week.

INFILTRATION RATES

The spoil material was tested to determine the rate at which water would infiltrate into the backfill under saturated conditions. Because of the large variability in surface particle size, a large variation in infiltration rates was also expected. Standard percolation tests were run by preparing a hole approximately 20 cm deep, saturating the hole with water for 24 hours, refilling the hole with water after the 24 hour period and then measuring the change in water level with time. Attempts were made to case the holes with 15 cm (6 inches) PVC pipe but due to the bouldery nature of the material, the tests were run on uncased holes.

Two areas in the western portion of Basin #1 and two areas in the eastern portion of Basin #7 were tested. The range between infiltration rates at various sites was 2.5 cm/hr. The lowest value obtained was 0.83 cm/hr (0.3 in/hr), the highest was 3.25 cm/hr (1.25 in/hr), and two sites had values of 2.0 cm/hr (0.8 in/hr). These values are significant because they substantiate the observations that minimal surface runoff occurs during most storm events. Given these high infiltration rates and assuming that the variation would be greater if more areas were tested, the spoil material will afford very little runoff during most storm events.

SECTION 6

RESULTS AND DISCUSSION

GROUND WATER QUALITY

Sample Collection and Data Presentation

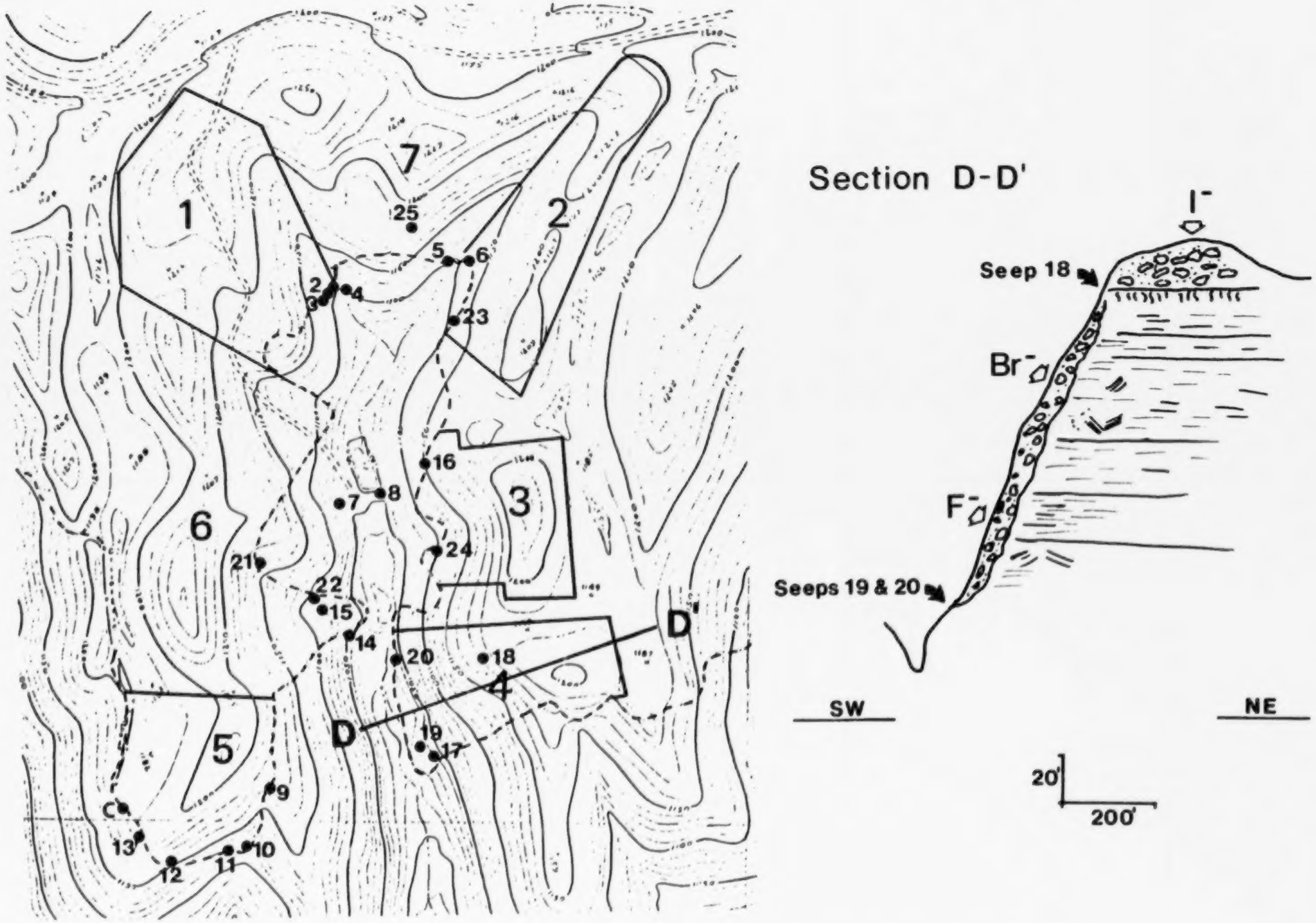
Between the summer of 1979 and the fall of 1981, each of the twenty-five seeps was checked on a weekly basis. Each seep was either noted to be dry or if it was flowing, a sample was collected. From the alkaline seeps two samples were collected; one was shipped directly to the University of South Carolina along with the acid samples and the other was analyzed at Belmont Technical College within twelve hours for pH and alkalinity. All samples were packed in coolers, shipped and then analyzed upon their arrival at U.S.C. The data collected from each of the 26 samples (25 seeps plus rainfall) were tabulated and appear in Appendix A. All of the ponds surrounding the site were analyzed in April, 1979, and these data are included at the end of Appendix A.

The seeps generally occurred at the boundary between the affected area and non-affected area. However, several seeps such as 18, 25 and perhaps 13, occurred at the approximate elevation of the seat earth. At these sites, water infiltrates through the spoil, contacts the impermeable underclay and then moves laterally and emerges as a seep. An example of this flow path is shown in cross section D-D' through basin 4 (Figure 8). The water infiltrates through the spoil, picks up the Iodide spike and emerges as seep 18. In some areas of basin 4 where there is more cast material covering the outslope of the seat earth, the infiltrating water follows the contact between the original, less permeable land surface and the cast overburden and emerges at the toe of the spoil instead of at the elevation of the seat earth (Seeps 17, 19, and 20). Ideally, the first tracer to be detected would be fluoride, then bromide and finally iodide if there was a direct relationship between the arrival time of the spike and the distance of the spike from the seep. From these data the travel time and hydrology could be established.

The Control Sites, Basins # 6 and # 7

Characterization of Basin # 6--

Basin # 6 is located in the west-central portion of the drainage basin. The seeps characteristic of this site were 7, 14, 15, 21, and 22. Seep 7 was a spring flowing from an area below the mined site but adjacent to a road which was built in order to access the upper pond. The seep was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Seep 18
Br⁻
F⁻
Seeps 19 & 20
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NE
20'
200'

Figure 8. Cross-section Through Basin #4 Along Line D - D'

alkaline but had a sulfate content which averaged approximately 800 mg/l. Although there was some fluctuation in weekly values, the alkalinity and sulfate remained relatively constant with time. Seep 15 was very similar to seep 7, however, the sulfate in seep 15 averaged nearly 300 mg/l higher (1100 mg/l). The minor fluctuations with time of the conductivity and alkalinity are clearly seen in Figure 9 as well as the minimal overall change in seep quality during the project. Because seeps 7 and 15 are very similar, only the plot of seep 15 is presented (Figure 9).

Seep 14 flowed occasionally during the first nine months of the study, but after that time remained dry. This seep was alkaline but did not flow for a sufficient period of time to reflect any changes in water quality.

Seeps 22 and 21 were acid seeps; seep 21 was a high acid seep with acidity values ranging from 1500 to 2500 mg/l acidity as $CaCO_3$ (Figure 10) and seep 22 was a low acid seep that became alkaline. However, the neutralization of seep 22 is primarily due to its juxtaposition with seep 15. Seep 15, as seen in Figure 9, was always alkaline but the flow, as shown in Appendix A, decreased significantly over the period of the study. The flow of seep 21, (located 2 feet north of seep 15) increased over the same time frame and the acidity levels decreased. This suggests that the decrease in acidity in seep 21 is probably a function of changing internal flow paths within the backfill and that the change in quality is due to the increased flow from seep 15 to seep 21 rather than the overall change in ground water chemistry from acidic to alkaline.

Characterization of Basin # 7--

Basin # 7, located in the northern portion of the drainage basin, is an untreated, control site spiked with a bromide tracer and is characterized by seeps 4, 5, and 25. A portion of the source of seep 1 may be from this basin but tracers were never detected in the samples of seep 1 so it is difficult to definitely determine the source of this seep.

All seeps from this control site were moderately acidic seeps and exhibited a similar trend of slightly decreasing acidity values with time. Due to their chemical similarity, Figure 11, which is the plot of the drainage quality of seep 5 demonstrates these changes with time.

In Figure 11, it is difficult to observe the decrease in values, especially acidity, with time. Therefore, a regression analysis of the acidity lines was calculated as: $y = -3.49x + 804$, $r = 0.8$ where y = acidity as mg/l and x = time in days. The resulting low, negative slope of -3.49 indicated that a small decrease in the acidity was in fact occurring with time even though no limestone had been used in this basin. Although during the time frame of this study the decrease in acidity appears to be linear, it is doubtful that this would remain linear for extended periods of time and is probably a function which asymptotically approaches zero.

An asymptotic function is more realistic because the pyrite which is currently oxidizing and producing acidity, is not the only pyrite available.

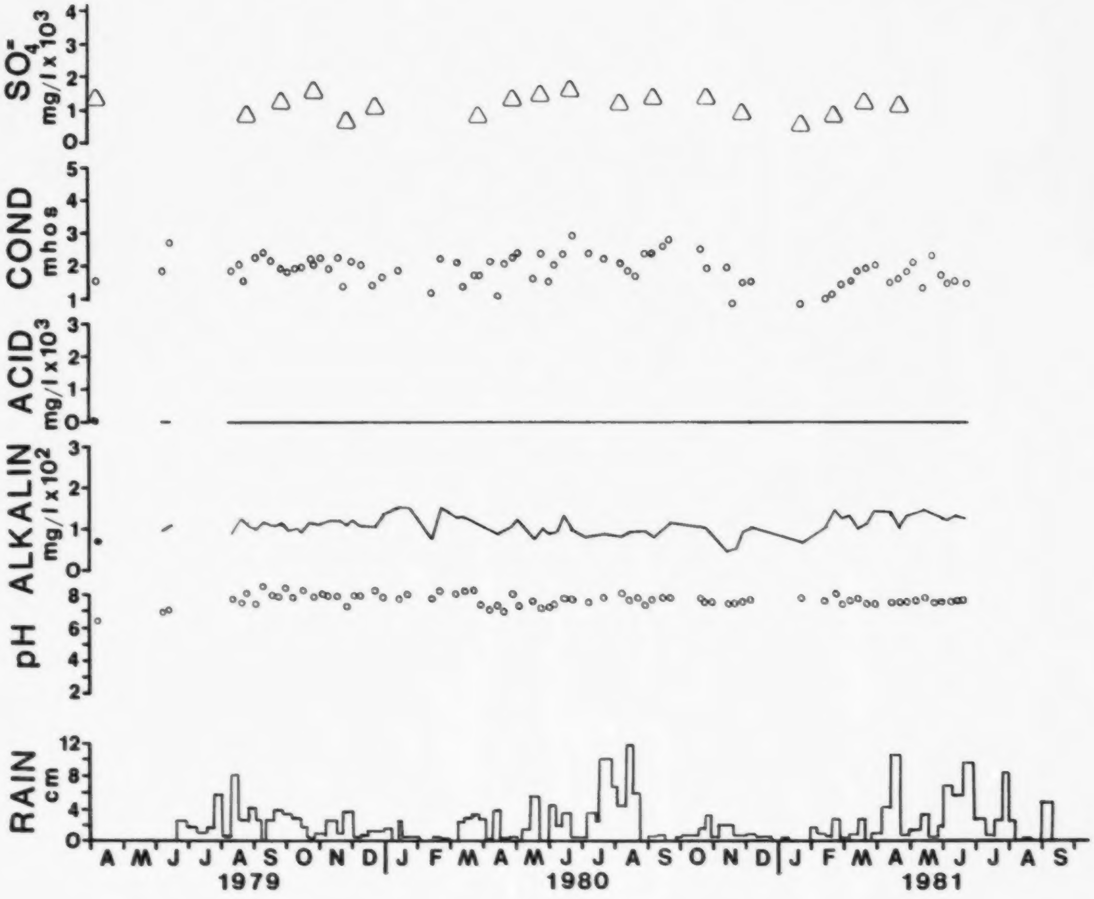

Figure 9. Drainage Quality of Seep #15

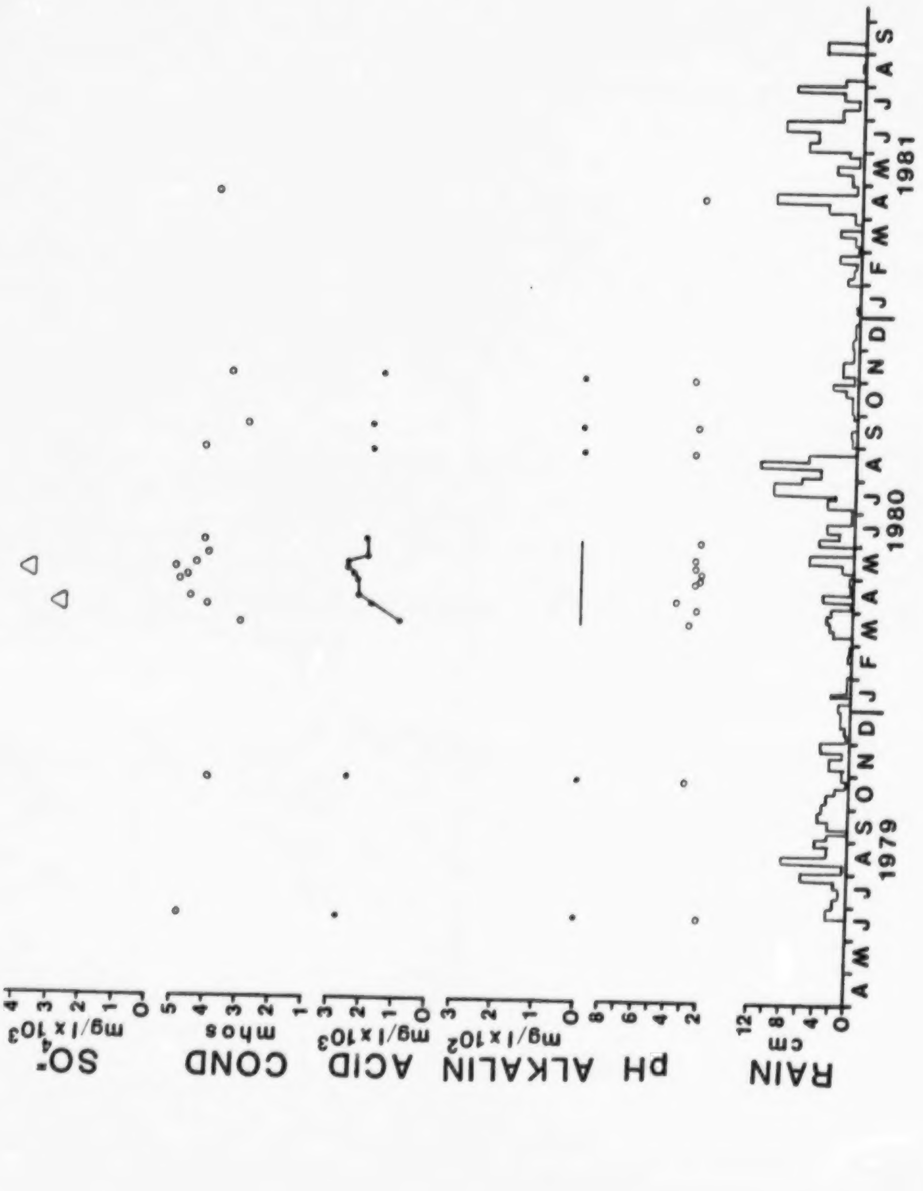

Figure 10. Drainage Quality of Seep #21

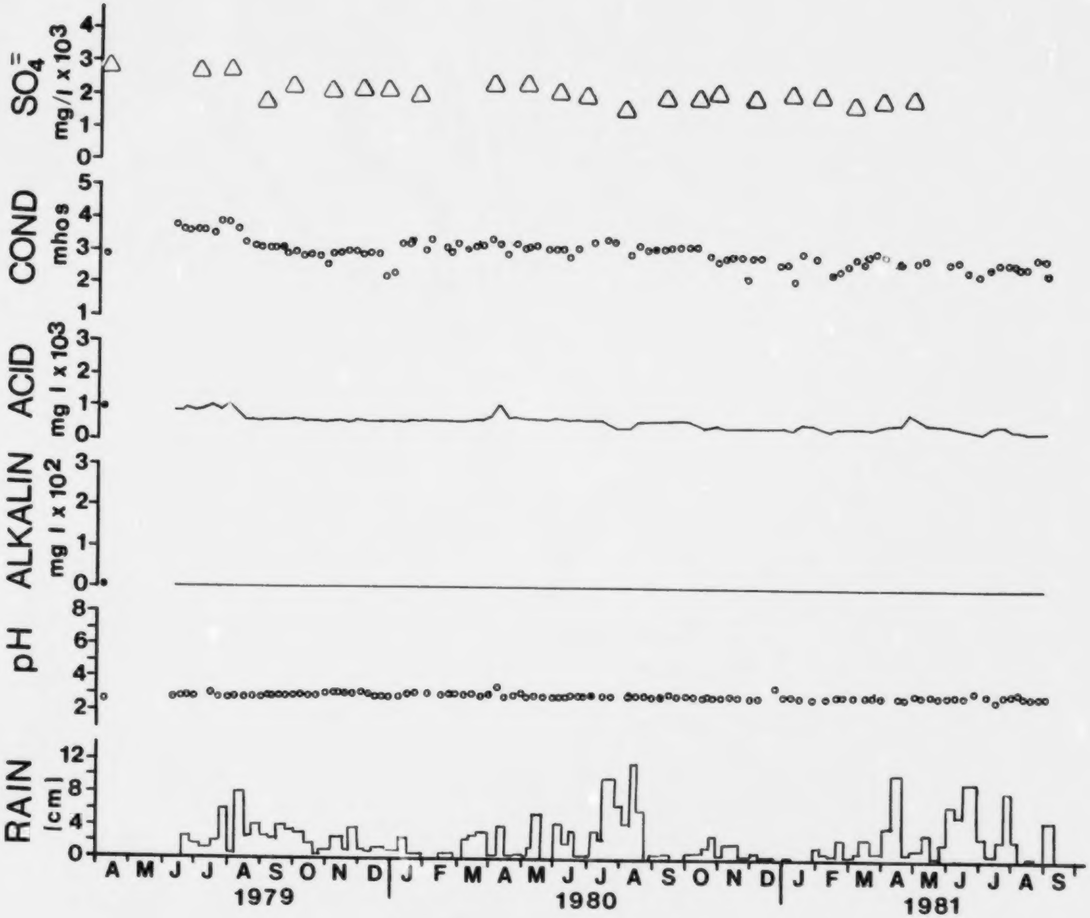

Figure 11. Drainage Quality of Seep #5

Much of the pyrite occurs as nodules with the outer portions of these nodules currently being oxidized. However, these outer layers will be stripped away and new pyrite surfaces exposed for oxidation. Several of these nodules were collected from the surface of the mine and because of their size, it is doubtful that they could physically decompose and oxidize completely in a couple of years. Additionally, these nodules are contained within sandstone blocks and the interior nodules may not be available for immediate oxidation; it is only with time that these blocks will decompose and the pyrite will be available for oxidation. Therefore, although we are seeing a decrease in the acid concentrations with time and over a two year period the decrease appears linear, longer observation would probably show a continued decrease in acidity with time but the decrease would asymptotically approach zero.

Characterization of Treated Basin # 1

Basin # 1 was treated with 97 metric tons/ha (43 tons/acre) and is characterized by seeps 2 and 3. Again, seep 1 is influenced by both Basin 1 and Basin 7 and although an iodide tracer was detected once in March and once in April of 1981, this does not indicate that the only source of water for seep 1 is from Basin #1.

Seep 2, as seen in Appendix A, has high acid concentrations, a sustained flow of approximately 0.5 cfs and a temperature which fluctuates between $10^{o}C$ and $15^{o}C$. The relatively constant temperature indicates that the source of seep 2 is a relatively deep ground water system. The seep quality is graphically depicted in Figure 12.

The acidity, sulfate, and specific conductance of seep 2 are all decreasing with time while the pH is increasing slightly. A regression analysis confirmed the decreasing values with time and also showed that the acidity was decreasing at a faster rate than the acidity from seep 5, the control site. The equation of the line was: $y = -7.19x + 2162$, $r = 0.61$, where y = acidity as mg/l and x = time in days.

Additionally, the acidity and sulfate values of seep 2 and seep 5 were compared to determine variations in the rate of change by the following equation:

$$(C-T)-(K) = x \qquad [9]$$

where C is the control seep 5, T is the treated seep 2, and K is the average difference between the two seeps during the first 120 days of monitoring from April 4 to July 30, 1979. The period of K was taken as a time interval when the treated site was not being affected by the treatment. If (C-T)-K is equal to zero during the time frame of the study, then the change in acidity with time is the same for both the treated and the control sites. If (C-T)-K is positive, then the acidity level of the treated site decreased at a faster rate than the acidity of the control site. On the other hand, if (C-T)-K is negative, then the acidity level in the untreated control site is actually decreasing faster, under natural conditions, than the area treated with limestone.

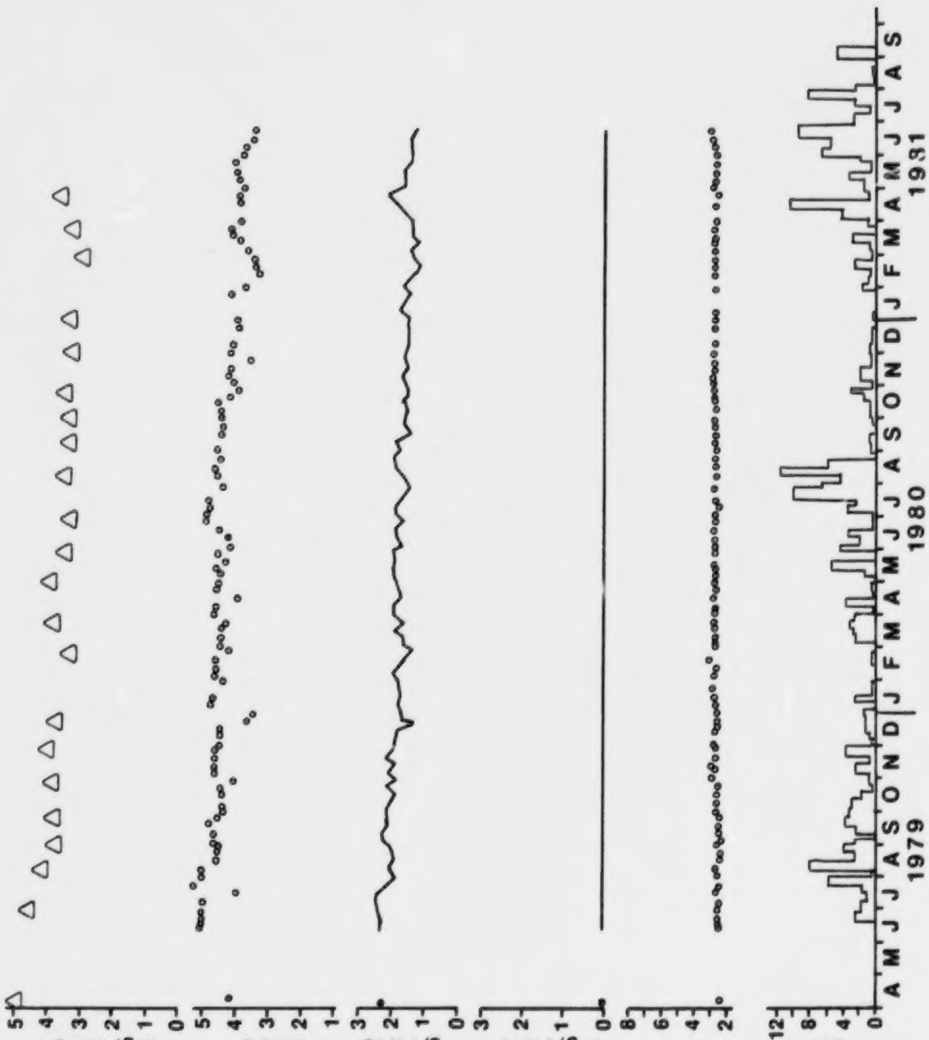

Figure 12. Drainage Quality of Seep #2

When seeps 2 (treated) and seep 5 (control) were compared, (C-T)-K averaged zero for the first 250 days and then became positive for the remainder of the study. This indicates that the level of acidity from the limestone treated area was decreasing at a faster rate than the untreated area and that the limestone was effective in reducing the amount of acidity produced.

The decrease in acidity levels from the limestone treatment could be due to either simple neutralization of the acidity or a change in the oxidation rate of pyrite. In order to evaluate which mechanism dominated the change in acidity levels, the acidity-sulfate ratios were evaluated in conjunction with the (C-T)-K values. If neutralization was the dominant factor in acidity reduction, then the acidity-sulfate ratio would decrease, the (C-T)-K for acidity would be positive and the (C-T)-K for sulfate would show no change with time (i.e. (C-T)-K = 0). However, if the limestone application affected the pyrite oxidation reactions, the the acidity-sulfate ratios would remain the same while (C-T)-K values for both the acidity and sulfate would be positive and increase with time. A third possible situation could occur when the acidity decreases with time but, the acidity-sulfate ratio remains the same, the (C-T)-K value for acidity equals 0 and the (C-T)-K for sulfate is either zero or decreasing slightly. Under these conditions, the water quality is similar to that from the control sites and the limestone is not affecting the water quality.

When these criteria were imposed on the data from seep 2 compared to seep 5, the results indicated that the pyrite oxidation was being affected by the limestone treatment and that neutralization was not the mechanism responsible for the decreased acidity levels. The (C-T)-K for acidity and sulfate were both positive and increased with time, while there was no change in the acidity-sulfate ratio. The results of these comparisons are given in Table 3.

Seep 3 is located on the border between the affected and unaffected area. In this case, no spoil was cast over the existing topography on the south side of seep 3 but it was cast on the north side. Therefore, seep 3 does come out of the toe of the spoil but drainage may come from both the spoil and the unaffected area. This may help to explain the drastic fluctuations in the quality of seep 3 as seen in Figure 13.

Seep 3 was initially alkaline with values which averaged around 150 mg/l as $CaCO_3$. However, within a one week period the sample could become highly acidic. The first such change occurred in August 1979, but after being acid for two weeks, the seep again became alkaline. Then in the spring of 1980, the seep again became highly acidic with acidities of up to 1100 mgs/l, but one week later turned alkaline.

It should be noted that the iodide tracer was detected during the times when the system was alkaline but was never detected while it was acid. This suggests that the flow paths feeding the seep changed with time. Because this is probably not a typical water table as would be found

Table 3. Basin Evaluations of the Mechanisms Responsible for Decreased Acidity with Time

			Seep Characteristics													Mechanism Responsible for Decreased Acidity		
			Acidity with Time			$(C-T)_{H^+}-K$			$(C-T)_{SO_4^=}-K$			$H^+/SO_4^=$					
			Inc.	Dec.	no change	>0	=0	<0	>0	=0	<0	Inc.	Dec.	slight dec. -no change	Behavior similar to control	Neutralization	Pyrite Oxidation rate affected
0 t/a	Control Seeps	Seep 5		X			X			X				X	X		
		Seep 25		X			X		*F	F	F			X	X		
		Seep 4			X	F	X	F	F	X	F			X	X		
		Seep 22		X			X		F	F	F		X		X	X	
43 t/a	Basin 1	Seep 2		X		X			X					X			X
36 t/a	Basin 3	Seep 24		X		F	X		X	F				X			X
37 t/a	Basin 5	Seep 10		X		X	F	F	X	F	F			X			X
		Seep 11		X		X			X				X	F		X	X
50 t/a	Basin 4	Seep 19		X			X			X			X		X	X	
67 t/a	Basin 2	Seep 23		X			X		F	X	F			X	X		
		Seep 6		X			X			X				X	X		

Ideal Characteristics	Behaves as Control		X			X			X				X	X		
	Neutralization		X		X				X			X			X	
	Pyrite Oxidation		X		X			X					X			X

*Fluctuates, trend difficult to discern

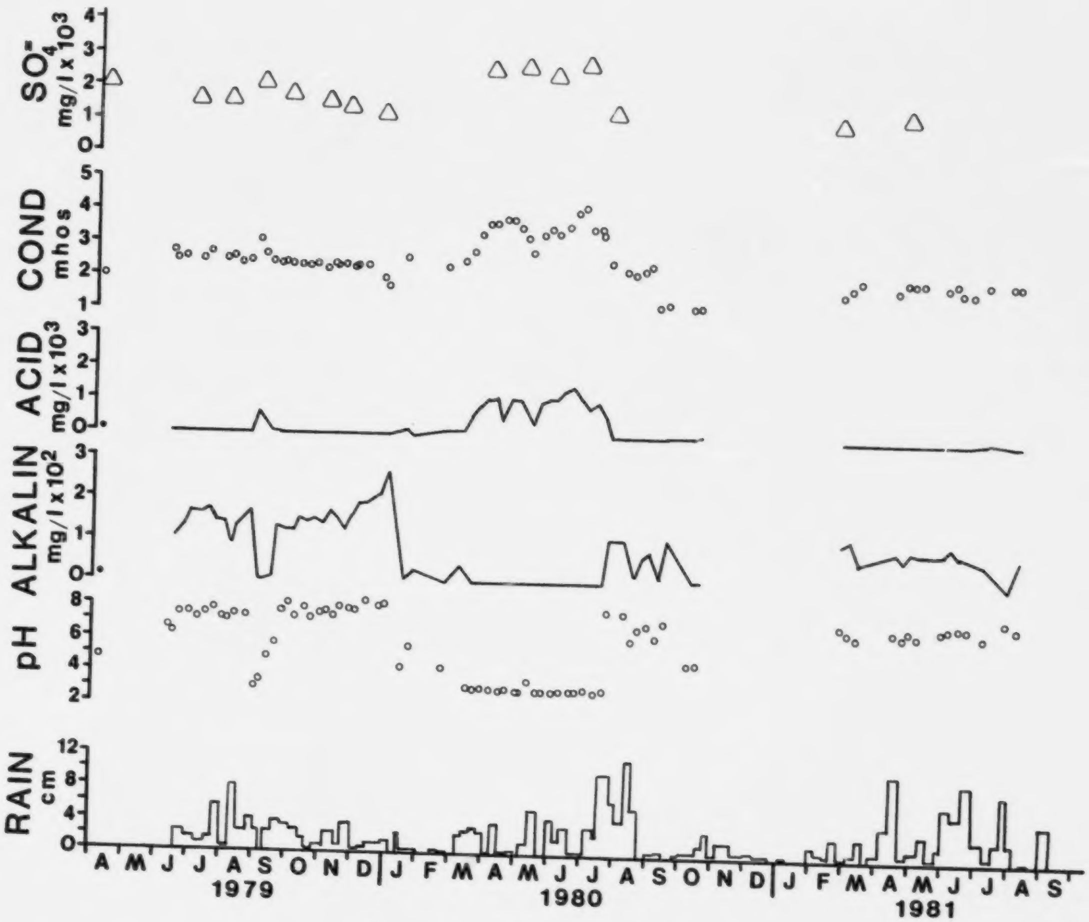

Figure 13. Drainage Quality of Seep #3

in unconfined homogeneous material, the ground water may follow particular paths through the spoil. These paths could, from time to time, become blocked with particles or for some other reason, change course. In so doing, they may wash over more pyritic material or less alkaline material, thus changing the seep quality.

There is a strong relationship between the acidity and sulfate in this seep; the greater the acidity, the greater the sulfate concentration. This relationship suggests that the high alkalinities are due to less pyritic oxidation affecting the seep quality. If the seep were only being neutralized, the sulfate should remain relatively constant while the acidity decreased. In this case however, the acidity decreases, alkalinity increases and the sulfate decreases to around 1500 mg/l. This background or base value of 1500 mg/l is similar for most of the alkaline seeps from the affected area. Seeps 14 and 15 from the control Basin # 7 also had sulfate values in this range. The high value of background sulfate in these seeps indicates that either 1) a certain amount of neutralization is occurring or that 2) gypsum (a calcium sulfate mineral) may be present in the section. However, no gypsum was noted to occur in the geologic section in this area (Berryhill, 1963).

In seep 3 (Figure 13) when the tracer was first detected, there was an attendant increase in the alkalinity. It is possible then, that when the flow paths follow a route forming on alkaline drainage, the alkalinity is increased by the limestone surface covering.

In summary, Basin # 1 was characterized by seeps 2 and 3. Seep 2 was highly acidic but did show a slight decrease in acidity with time and seep 3 was either alkaline or highly acidic depending on the internal flow paths through the spoil. Based primarily on the acidity-sulfate ratios for both seeps and the (C-T)-K values for seep 2, the limestone treatment in this basin decreased the rate of pyrite oxidation which resulted in a decrease in the acidity levels with time.

Characterization of Treated Basin # 2

Basin # 2 was treated with 150 metric tons/ha (67 tons/acre) of limestone and is characterized by seeps 6 and 23. These seeps are both moderately acidic with acidity values averaging between 750 and 1000 mg/l. Seep 23 showed a greater decrease in acidity with time than seep 6. Seep 23 changed from an average of 1300 mg/l to an average of around 900 mg/l by August 1981. Seep 6 decreased only from about 680 mg/l to an average of 500 mg/l. The general pattern of decrease is similar for the two seeps as well as the percent decrease in the acidity levels. There was a 30% decrease in seep 23 and a 26.5% decrease in seep 6, therefore, the plot of seep 6, as shown in Figure 14, is characteristic of both seeps.

A regression analysis of seep 6 acidity resulted in a line with a slope which was less than that of seep 5 (the control basin) indicating a slower decrease in acidity in the treated area than in the untreated basin. The equation of the line was: $y = -0.32x + 572$, where y = acidity in mg/l and x = time in weeks. This slower decrease was also evident when

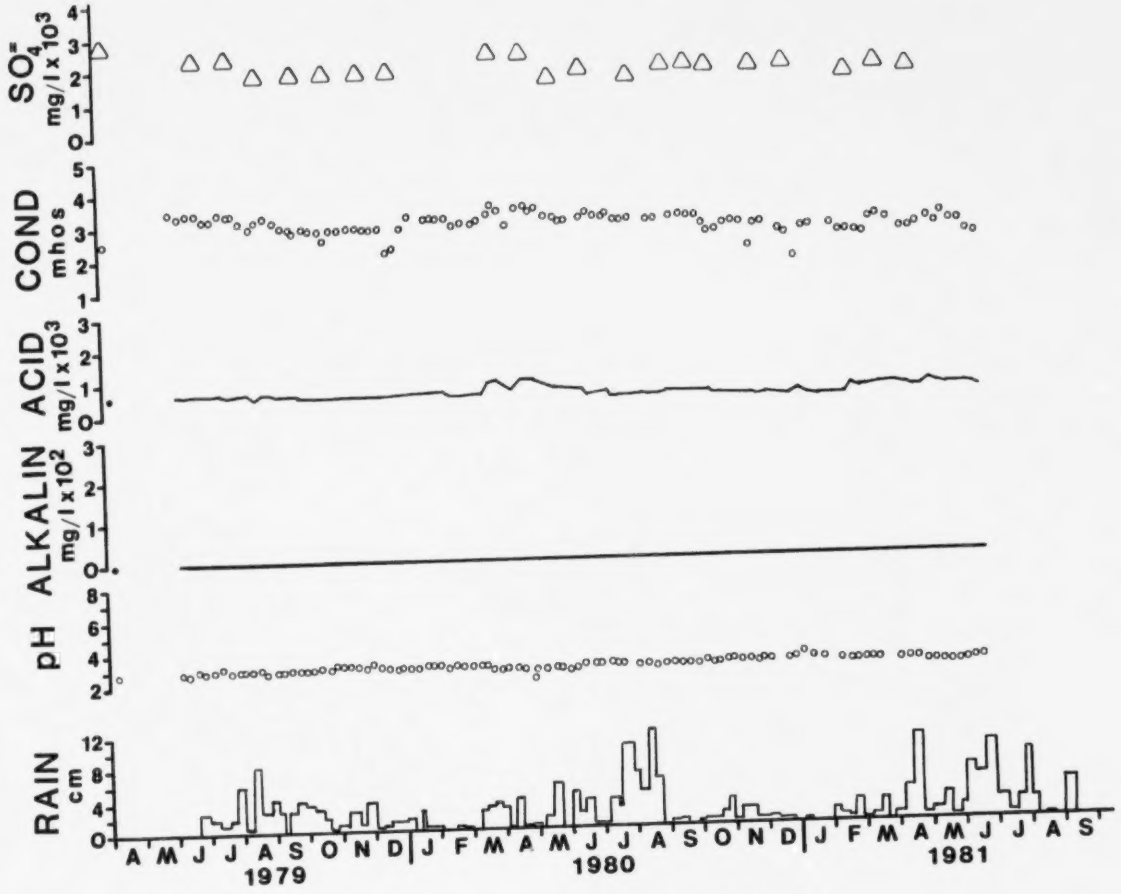

Figure 14. Drainage Quality of Seep #6

seep 6 and seep 5 were compared by equation [9]. For these seeps, (C-T)-K for acidity had a negative value after day 130 but after that time, the line was horizontal which indicates that the rate of decrease for the two seeps was similar. A comparison of (C-T)-K for sulfate also gave similar results while the acidity-sulfate ratio showed no change with time. These results as shown in Table 3, indicate that the improvement in seep quality is similar for both the treated seep 6 and the control seep 5.

A comparison between seep 5 and seep 23 yielded similar results, however, the (C-T)-K for sulfate for seep 23 had greater fluctuations. Therefore, based on the comparisons of both seeps 6 and 23 to seep 5 (Table 3) coupled with the lack of detection of the tracer, the limestone was not significantly affecting the water quality up to this time and these seeps responded similarly to the control seeps.

Characterization of Treated Basin # 3

Basin # 3 was treated with 80 metric tons/ha (36 tons/acre) of limestone and is characterized by seeps 16 and 24. Seep 16 flowed for only 6 months of the study; it went dry in November 1979 and did not have a sufficient flow to sample after that time. Therefore, seep 24 has been used to characterize this basin. The treated area was spiked with a fluoride salt as a tracer which was detected once in the fall of 1979 and then was detected regularly from March 1981 through July 1981.

There has been a general decline in the acidity, sulfate, and specific conductance with time but, there was no major decrease after the detection of the fluoride. The overall percent decrease in acidity is similar to that in Basin # 2, about 30%, which, even though it is a 500 mg/l decrease over 2½ years, does not significantly improve the pH of the system. The initial pH was approximately 2.6 which increased to approximately 3.0 at the end of the study (Figure 15).

A comparison of seeps 24 and 5 by (C-T)-K for sulfate and acidity resulted in values which fluctuated greatly, however, there is an increasing trend for the sulfate and a non-decreasing trend for the acidity. These data, coupled with an acidity-sulfate ratio which exhibited no change with time (with the exception of one point on 12/1/79 when the ratio increased from an average of 0.4 to 0.79), indicate that the application of the limestone had a slight affect on the pyrite oxidation mechanism and that pyrite is not oxidizing as readily in the treated area as in the control site.

Characterization of Treated Basin # 4

Basin # 4 had 112 metric tons/ha (50 tons/acre) of limestone applied on the surface and is characterized by seeps 17, 18, 19, and 20. Seeps 17, 18, and 19 were initially mildly acidic and seep 20 was alkaline. Seep 20 was not significantly affected by the limestone application; the sulfate remained constant, although the specific conductance decreased slightly from 1500 to 1250 μmhos/cm. The alkalinity also decreased slightly from initial values between 200 and 180 mgs/l as $CaCO_3$ to values

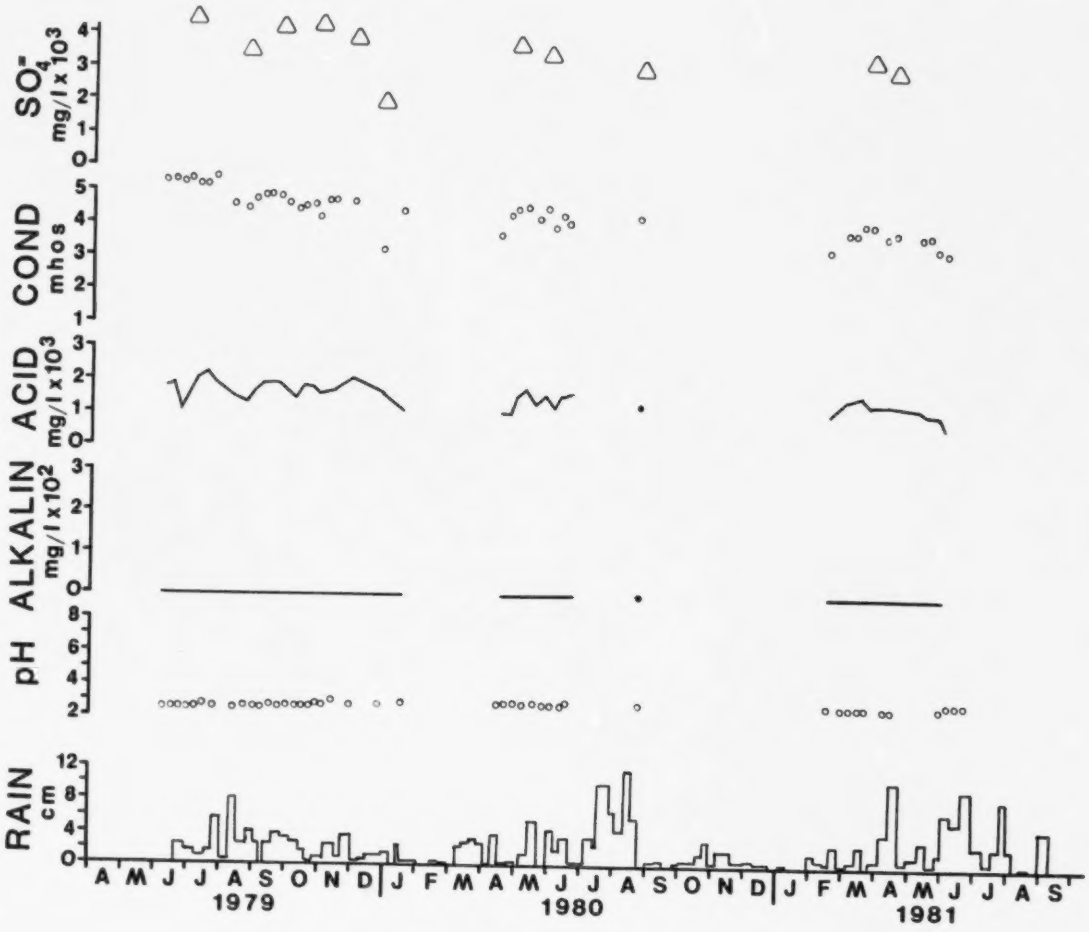

Figure 15. Drainage Quality of Seep #24

that fluctuated between 160 and 140 mgs/l. The average pH value also decreased from about 8 to 7.5.

Seeps 17 and 19 were mildly acidic seeps which behaved similarly and seep 19 is plotted to graphically depict the water quality changes with time in Figure 16. Both seeps emanate from the toe of the spoil approximately 40 m (130 ft.) below the original outcrop of the coal. The cast spoil covers the original contour with a shallow cover of between ½ to 1½ m (20 to 60 inches) of material. Seeps 17 and 19 are fed primarily from seeps which begin at the top of the hill and flow just below the surface to the base of the hill.

Seep 19 was mildly acidic at the beginning of the study. In the fall of 1979, the iodide tracer was detected and the pH increased. In mid-1980 the tracer was again detected, the pH rose and the system became alkaline. However, the seep went dry after that sample and when the flow resumed in the spring of 1981, the seep was acidic. Seep 19 remained acidic throughout the summer although the tracer was still being detected. One possible explanation for this phenomenon is that the pyrite continued to oxidize in the humid environment and because there was insufficient water for the seep to flow, the salts accumulated. Due to the shallow nature of the cast overburden, oxygen was available for pyrite oxidation and the rocks retained sufficient moisture for the chemical reactions to continue. When the alkaline water from the limestone treatment infiltrated during the spring, the amount of acidity which had accumulated in the spoil was greater than could be neutralized by the available alkalinity which resulted in an acid system. It is possible that with time, this seep could return to an alkaline condition.

Seep 19 was evaluated by comparing the (C-T)-K for both acidity and sulfate and the acidity-sulfate ratios (Table 3) and the results indicated that neutralization was the primary mechanism responsible for the decreased acidity. It is suggested, therefore, that the limestone application slightly enhanced the neutralization of the acid seeps which resulted in seep 19 becoming alkaline.

Seep 18, as seen in Figure 8 earlier in section six, emerges from the side of the hill at the level of the seat earth. This seep initially had a low acidity, between 50 to 70 mgs/l as $CaCO_3$, and after the tracer was detected in October 1979, the system turned alkaline as seen in Figure 17. The system remained alkaline, although it had the characteristic high sulfate concentrations, until August 1980 when it went dry. It is postulated that the dry state may be due to changes in the internal flow paths and that instead of emerging as a seep at the original location, the water remained below the ground surface and contributed flow to the seeps at the base of the hill.

Characteristics of Treated Basin # 5

Basin # 5 was treated with 83 metric tons/ha (37 tons/acre) of limestone and seeps 9, 10, 11, 12, 13 and C were used to determine the changes in water quality as a result of the application. Seep # 9 was

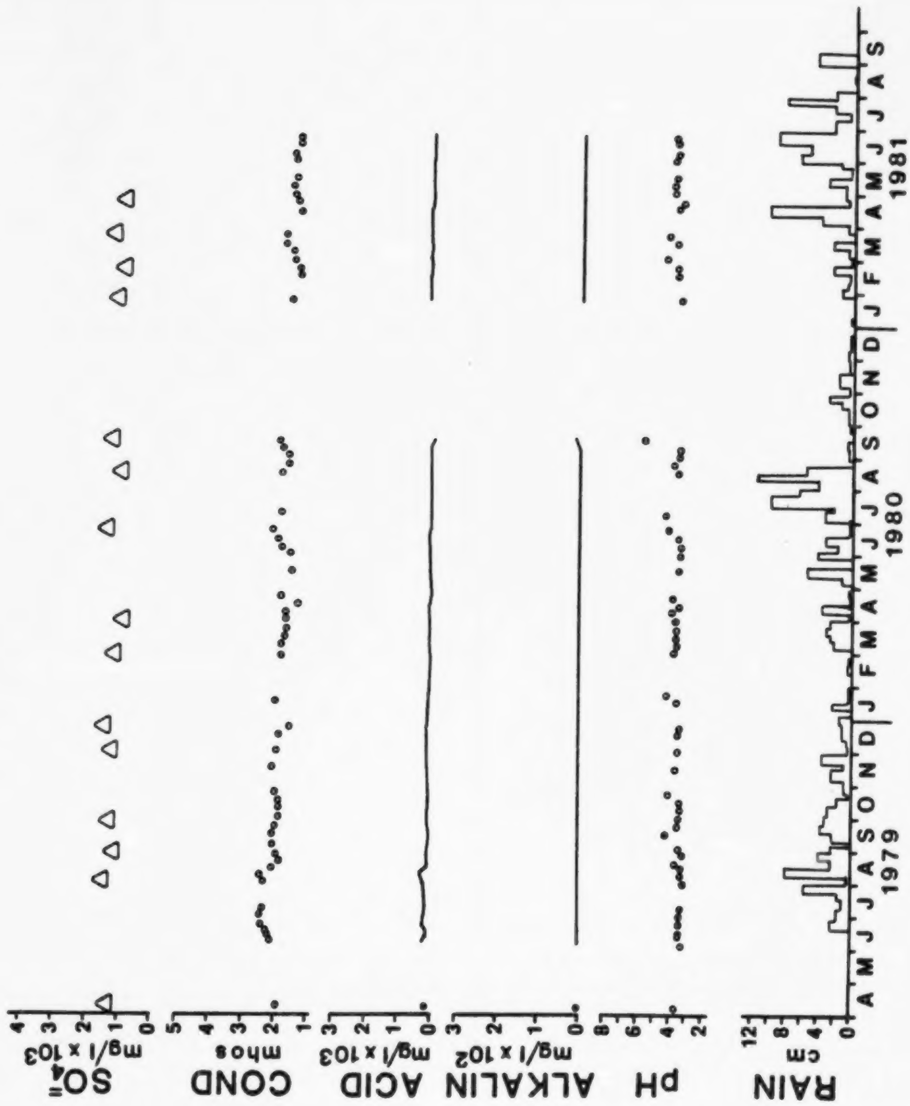

Figure 16. Drainage Quality of Seep #19

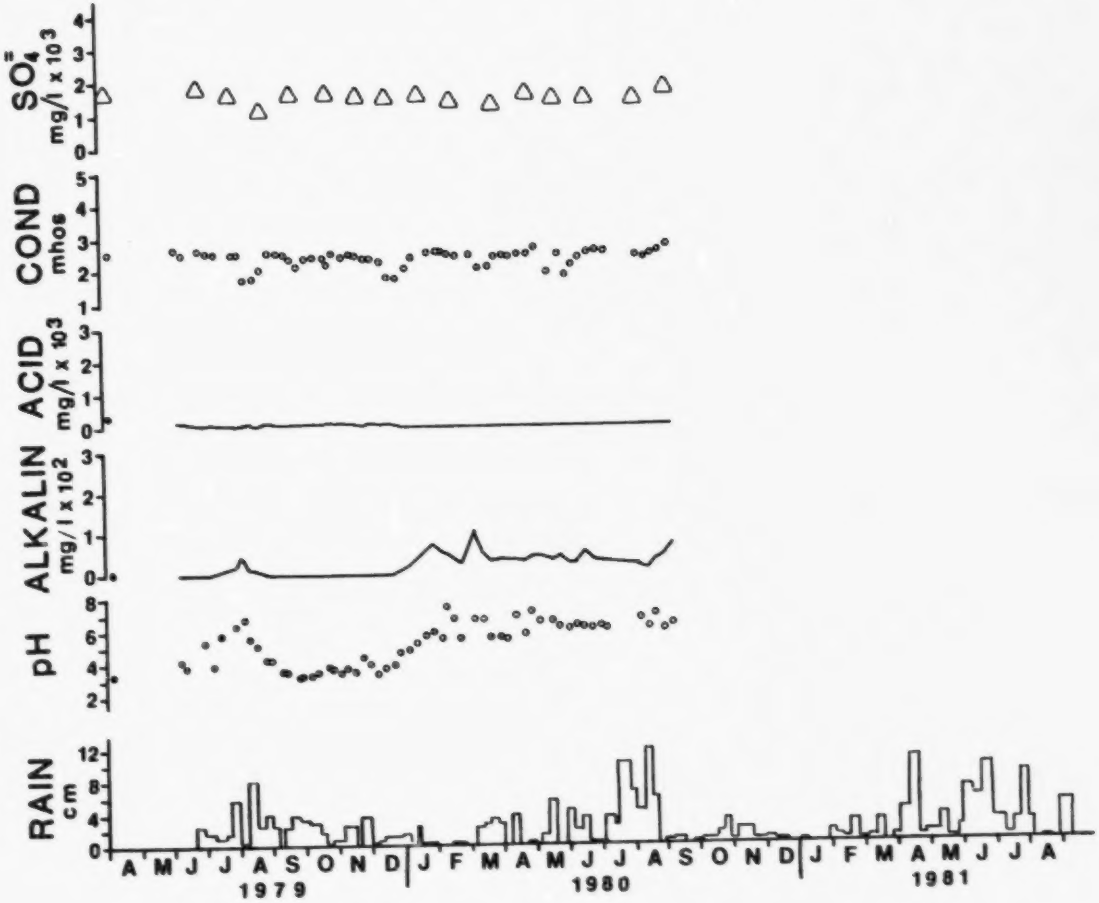

Figure 17. Drainage Quality of Seep #18

flowing during the preliminary survey of the area in April 1979 but flowed for only one or two weeks each year in the spring. Therefore, this seep was not used to characterize Basin # 5.

Seeps 10, 11, and 12 are very similar, high acid seeps. Seeps 11 and 12 flowed intermittently but the trends are similar to those of seep 10 which are shown in Figure 18. There was a slight decrease in the acidity level with time which is substantiated by a negative slope calculated from a regression analysis of seep 10 where $y = -8.61x + 1905$. The sulfate values did not significantly decrease during the period of this study although they did fluctuate considerably. Based on laboratory tests which estimated that the maximum available alkalinity would be approximately 70 mgs/l as $CaCO_3$ it was not anticipated that the limestone would completely neutralize these seeps, rather this basin served as the "worst case" to determine which levels of acidity could be affected (either by neutralization or changing the rate of pyrite oxidation) by the limestone.

Seep 13 emerges as a seep at the approximate elevation of the seat earth. The acidity, sulfate and specific conductance values are not as high as those from the seeps coming from the toe of the spoil. The acidity ranges from approximately 500 mg/l to 290 mg/l and pH values from 2.9 to 3.3. The regression analysis indicates that there was a slight decrease in acidity during the two years, and even though the slope of the calculated acidity line ($y = -187 x + 501$; where y = acidity and x = time in weeks) is less than that of seep 5 (the control site) the percent decrease in acidity is significant at 42%. This seep did not flow for nearly 11 months but the area was moist in the vicinity of the seep. Because the acidity level was not high after the long non-flowing condition it is suggested that because the area was moist, some flow was occurring below ground surface but that the water table was not high enough to intercept the ground surface at the sampling location. The return to flowing conditions of the seep was simply in response to an elevated water table condition.

Seeps 10 and 11 were evaluated by (C-T)-K for acidity and sulfate and their acidity-sulfate ratios were compared. The results for Seep 10 indicate that the decrease in acidity during the winter months of November through March is greater for seep 10 than the decrease in acidity for the control seep 5. However, during the spring and summer, the values for (C-T)-K for acidity change between positive and negative and suggest that during these periods the decrease in acidity levels is similar for both the treated area of seep 10 and the untreated seep 5. Seep 11, however, has a consistently increasing a (C-T)-K value for both acidity and sulfate which indicates that the pyrite oxidation rate was being affected. The acidity-sulfate ratio, however, decreases with time which suggests that neutralization is occurring simultaneously with the decrease in the rate of pyrite oxidation. Therefore in Basin 5, it appears as though the limestone is not only affecting the pyrite oxidation but is also acting as a neutralizing media.

Seep C which is located in Basin 5 does not actually reflect the quality of that basin; rather it reflects the water quality of the western

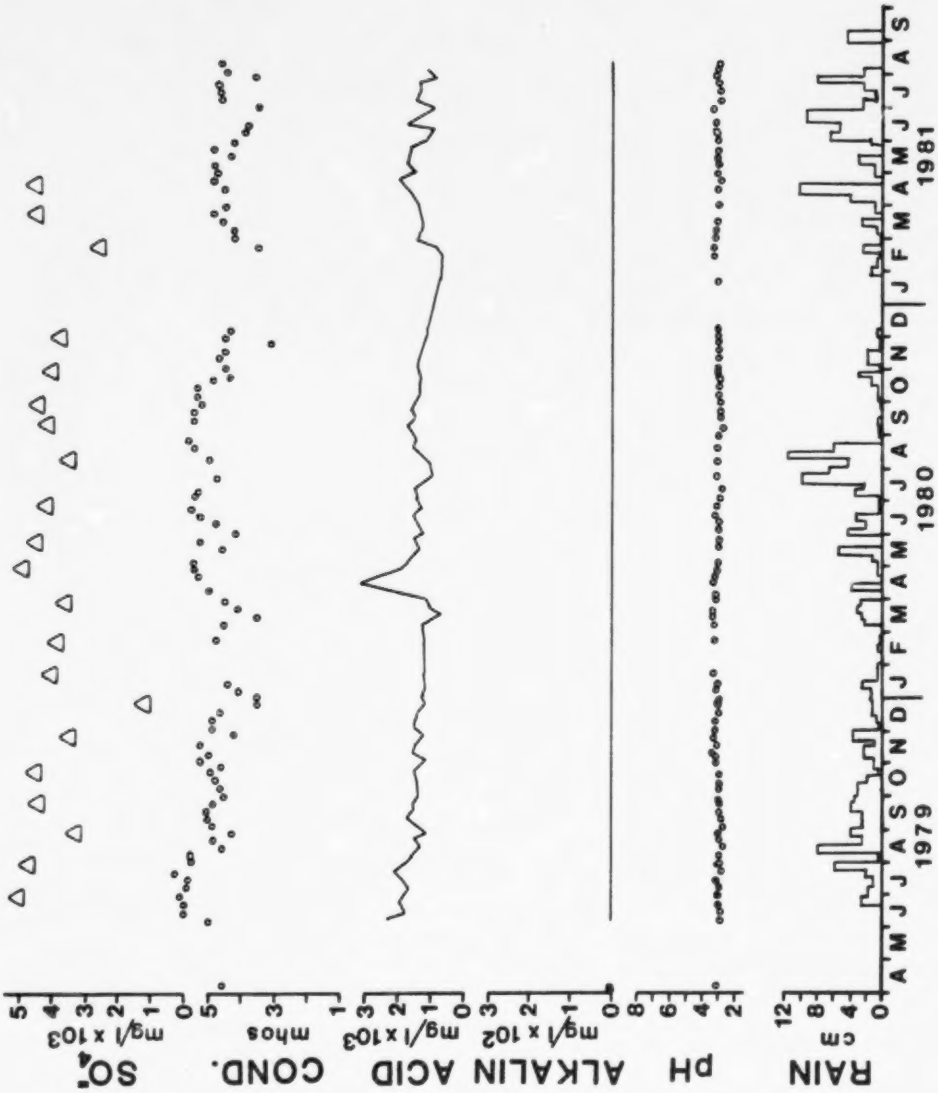

Figure 18. Drainage Quality of Seep #10

portion of the drainage basin. Seep C is a stream sampling point at the junction of the mined and non-mined areas. The stream drains three ponds: the first is immediately south-west of Basin # 1 and designated pond A; the second is west of Basin # 6 and denoted as pond B; and pond C is located in the western portion of Basin 5. During periods of high flow all three ponds are connected by a surface stream, however, during low flow periods, no surface stream is visible. The ponds are located at the approximate level of the seat earth although during the 12 years since mining, the area has filled in with fine particles so that the seat earth has been covered. The ponds are fed by rainwater, runoff and to a small degree by ground water bleed from the spoil. The latter is indicated by the relatively good quality of the ponds as shown in the table at the end of Appendix A. If a major source of the pond water was ground water bleed, the ponds would be more acidic and have higher sulfate concentrations. The impact of the ground water bleed is seen in seep C, Figure 19, where coincident with a high rainfall event and thus an increase in rainwater and runoff components, is an increased pH and either decreased acidity or increased alkalinity. To point out a few examples are the high rainfall events of July and August 1979 when these events elevated the pH to 5.8 and 6.2 respectively. Other examples are July and August 1980 and April and June 1981. During dry periods, such as the winter of 1980, the ponds were not flowing and the stream C was actually a seep which emanated about 10 feet in elevation below pond C. Under these conditions, seep C is acidic with high specific conductance which indicates that the major source of water was from ground water bleed through the spoil material. Additional evidence for ground water bleed is that the tracer is detected only during the acid, low flow periods. The tracers were placed below the ground surface to prevent detection of tracers in the seeps in response to surface water runoff. Therefore, because tracers were detected only under low flow conditions, it was assumed that ground water bleed caused the acidic conditions.

RAINFALL QUALITY AND QUANTITY

The rainfall quality in this area of Ohio is a mildly acidic rainfall with a pH that varies between 3.0 and 6.2. The rainfall quality is not consistent from one storm event to the next, rather it fluctuates appreciably. The rainfall was commonly acidic with acidity levels which ranged from 0 mg/l to 37.5 mg/l. However, there were five net alkaline rainfall events between June 1979 and July 1981. Several possible explanations for these alkaline events exist: first, the rainfall may in fact be alkaline. However, if pure water is in contact with the atmosphere and carbon dioxide, the water would have a pH of approximately 5.5. Second, the rainwater may have been neutralized. Rain samples which had pH values greater than 5.5 may indicate that alkaline materials have neutralized the rainfall. This possibility exists because mining activity in the area surrounding the site generated dust during dry periods. Some of the dust may have had sufficient neutralizers to produce alkaline rainfall as the rain passed through the dusty atmosphere. Selected rainfall samples were analyzed for calcium and on 5/12/80 and and 6/3/80, when the rainfall was alkaline, the calcium concentrations were 8.5 and 2.4 mg/l respectively. Rainfall events which were acidic had calcium values less than 1.0 mgs/l; on

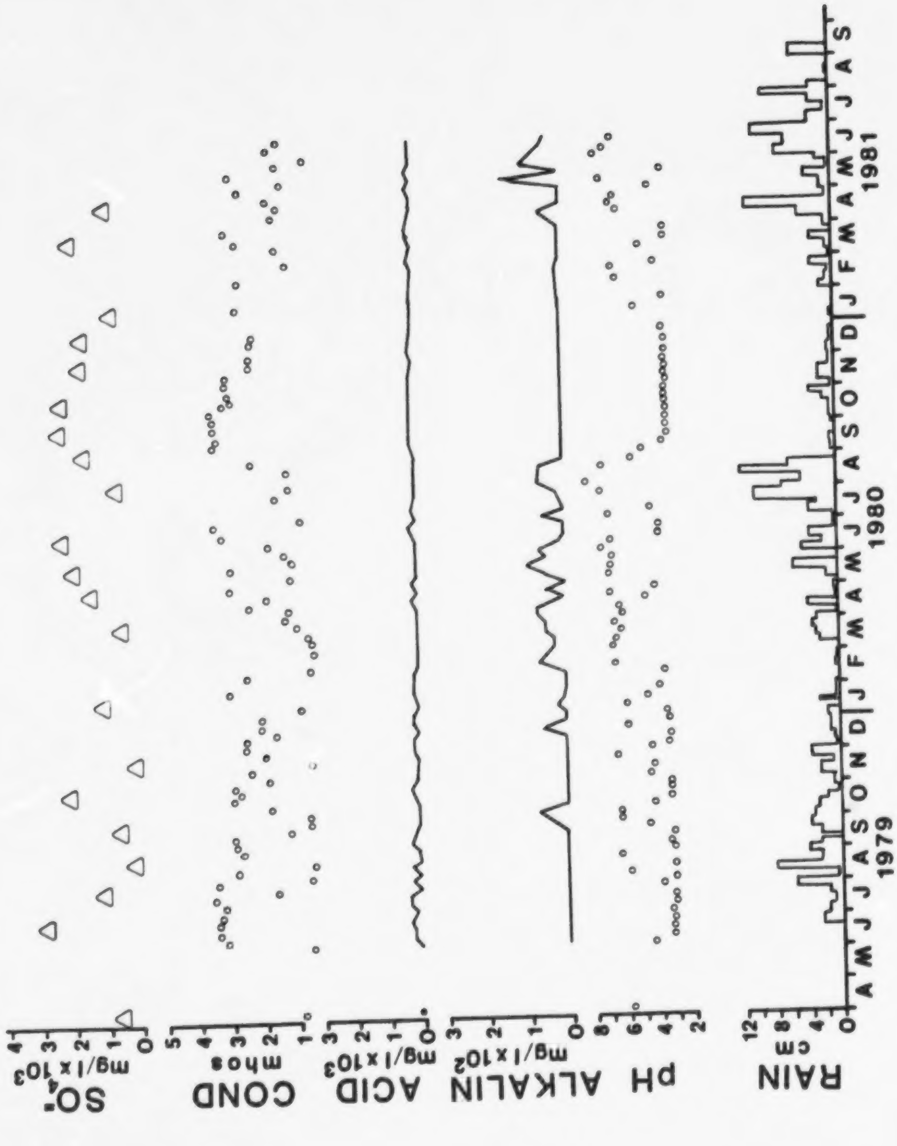

Figure 19. Drainage Quality of Seep C (Stream Sample)

7/25/80, 8/22/80, and 9/7/80 the values were 0.40, 0.15 and 0.95 mgs/l respectively. These results tend to confirm the hypothesis that the acid rainfall was neutralized during the storm event.

The rainfall histograms plotted on each graph of seep quality were derived from the weekly total rainfall measured with the recording rain gage. Although the gage does give a continuous plot of rainfall quantity and intensity, both of these parameters were reflected by the weekly summation of rainfall data. These values were compared to those obtained at the site to determine if and what variations occurred and with the exception of a few storm events, the total precipitation measured at the two sites was similar.

TRACER STUDY AND HYDROLOGY

The tracer study was used not only to determine when the seep quality was being affected by the limestone treatment but also to determine the flow paths of water through the spoil and the length of time required for rainfall to infiltrate through the spoil and emerge as a seep. Percolation tests conducted on the spoil provided an estimate of the infiltration rates which were found to vary from 0.3 to 1.5 inches per hour. From these estimates it was anticipated that the tracers would take between two months to two years to migrate through the spoil.

With the exception of Basin #2, tracers were detected in all basins during the course of the study. In basin #1 the iodide tracer, with which that basin was spiked, was detected in both seeps 1 and 3. In seep 1 the tracer appeared one year and eight months after the initial application while in seep 3 the iodide was first detected after four months but was not detected again for two years. Therefore, because the basin was spiked with iodide and iodide was later detected in the seeps, recharge in basin # 1 is most likely the source of the water for seeps 1, 2, and 3.

In basin #2, none of the tracers were detected in either seep 6 or seep 23. A lack of a tracer detection could be attributed to at least two factors. First, the rainfall flow-through time was greater than two years or, second, the source of the seeps was not from the spiked area. Because the entire area surrounding the seeps was spiked, one of the spikes applied in the area should have been detected if sufficient time had elapsed for rainfall to infiltrate through the spoil. Therefore, the most reasonable explanation for the lack of a tracer was that the flow-through time was greater than two years.

Basin #3 was spiked with fluoride and the tracer was detected during two short periods. It was first detected in early October, 1979 (approximately four months after application) and then again in April, 1981. Again, this showed that the area defined as the drainage basin for seeps 16 and 23 was the source of the water. Because there is a slight regional dip of 2^o to the east in this area (Berryhill, 1963), it is interesting to note that in basins #2, 3, and 4 the seeps occur on the western side of the spoil and that the tracers were detected in these seeps. That evidence indicated that the flow was from the east to the west, against the dip, within the basins #2, 3 and 4.

The best results from the tracer study were in Basin # 4. Seep 18 was located at the approximate elevation of the seat earth at about 1170' A.S.L. and the iodide tracer was placed in two locations above the seep at approximately 1195' A.S.L. Bromide and fluoride were also placed in this basin but below seep 18. The bromide was placed at about 1150' A.S.L. and the fluoride at 1100' A.S.L. The iodide was the first tracer to be detected and it was found in the sample from seep 18 on 10/9/79. This indicated that the flow through time for the water to travel the vertical distance of 7.6 m (25 feet) and the horizontal distance of 100 m (325 feet) was 4 months. If we assume that the rainfall infiltrated vertically until it encountered the seat earth and then traveled horizontally to seep 18, the total travel distance is 107.6 meters (350 feet). The shortest possible distance the tracer could have traveled was 100 m (325 feet), if it flowed immediately below the surface. However, because the differences between these two distances are not that great (100 m versus 107.6 m) and because it was more likely that the water infiltrated vertically the greater distance was used in the calculations. The water traveled through this material is about 125 days and if we assume a constant rate of movement, which may not be the case, the water moved at a rate of about 0.85 m/day (2.8 feet/day). A second approach is that the water infiltrated slowly through the upper material, then encountered a water table or at least a nearly saturated zone and the water flowed more rapidly. However, the most interesting result was that the iodide tracer appeared in seeps 17 and 19 at the base of the hill on the same day it was found in seep 18. This showed that the water flowed very rapidly down the hill, most probably at the interface between the premining topography and the cast material.

The bromide which was placed approximately 20 feet below seep 18 did not appear in either seep 17 or 19 until July 29, 1981 when bromide was detected in seep 19. The tracer was applied where it was estimated that the maximum depth of surface material was 1.5 meters (approx. 5 ft.) and where surface infiltration would be the primary water source. The flow paths for water in this area are obviously different than those discussed above with regard to the iodide tracer. In this case, it is suggested that on steep slopes the rate of water infiltration through the surface material was much less than that infiltrating through the material placed on top of the seat earth.

Basin #5, treated with both fluoride and bromide and with iodide placed on the north side of the border in basin #6, was affected by the limestone treatment after approximately six months as shown by the detection of fluoride in Seep 10. However, the entire area was not affected for up to 1.5 years when the tracer finally appeared in Seep 11. In seep 13 which was located above the fluoride spiked area, bromide was never detected but after one year iodide was measurable. This suggests that the flow paths in this basin do not flow in a southwesterly direction along the present topographic ridge but flow perpendicular to the ridge. This would explain why the bromide was never detected in seep 13.

In the control basins (basins #6 and #7), the tracer was first detected after six months and then not detected again until two years later. In basin #6, the iodide appeared in only seeps 15 (after two years) and 22 (after six months) and the bromide appeared after 2.1 years in seep 22. In basin #7, the bromide was detected in seeps 4 and 25. In seep 4, the first tracer was measurable after 1.75 years while in seep 25 the tracer was detected after six months, after one years and after nearly two years. The presence of bromide in these seeps indicated that the areas designated as the drainage basins for the control seeps were the source of the control seeps.

In summary, the tracer study delineated the drainage basins which were contributing to the seep drainage and showed that the drainage basins corresponded to the areas designated at the beginning of the study to be the source of those seeps. It was also found that the tracer appeared in the seeps twice. This was expected because the spike was applied once in June and again in late October. However, the initial detection of the seeps occurred after approximately four to six months while the second tracer appeared between 1.75 and 2 years. Ohio was affected by the drought of 1980 and this is the probable cause of the increased time interval between the first and second detection of the tracers.

VEGETATION

At the beginning of this study, many areas within this drainage basin were devoid of plant life. Although much of the site was vegetated with crown vetch, within each basin there were several acres where no vegetation had been established. After the mining operation, the entire basin was seeded (Cramer, personal communication) and over the years various species of trees including locusts and pine had been planted with varying degrees of success. Assessing the revegetation of this area in response to the application of limestone was not an objective of this study but several observations were made.

The area was spread with limestone in June 1979 but no additional seeding of the area was done. Through photography and personal observations, the vegetative stands of both the control and treated areas were monitored. During the summers of 1979 and 1980 only minor additional vegetation was noted to have grown. However, during the summer of 1981, all areas covered with limestone had a vegetative cover. Plant coverage varied between one and five plants per square foot in the limestone treated areas while control sites did not show any change in the vegetative cover during the same time frame.

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APPENDIX A

CHEMICAL ANALYSES OF SAMPLES COLLECTED FROM THE BEDWAY SITE, OHIO

Appendix A. Chemical Analyses of Samples Collected from Bedway Site, Ohio

Bedway Site, Fairview, Ohio
Sample Location # 1

Date & Time of Collection	Q	Temp. °C	S. Cond. umho/cm	pH	Acidity mg/l as $CaCO_3$	Alkalinity mg/l as $CaCO_3$	Sulfate mg/l	Tracer $Br^-F^-I^-$
11/17/78 12 noon	very low	10.5	2650	3.3	819	0.0	2575	- -
4/2/79 3 pm	very low	11.4	2200	3.3				- -
6/13/79 11 am	trickle	16	2810	3.4	1125	0.0		
6/16/79 12:30 pm	very low	20	2980	3.15	648	0.0		
6/22/79 1:30 pm		18	3100	2.99	868	0.0		
6/29/79 1:10 pm	slow	17	3510	3.00	1050	0.0	3775	- -
7/7/79 5:45 pm	low	21	3510	2.88	1142	0.0		
7/14/79 4:40 pm	low	23	3810	2.95	1483	0.0		
7/23/79 1:20 pm	slow	21.5	3690	2.89	1022	0.0		
7/30/79 12:13 pm	slow	22	3250	2.95	874	0.0	2440	- -
8/6/79 12:10 pm	slow	21	3490	2.92	907	0.0		
8/13/79 12:15 pm	slow	14	2820	3.02	591	0.0		
8/22/79 1:18 pm	slow	19	3050	2.84	895			
8/28/79 1:18 pm	slow	22	2650	3.00	547	0.0	1860	- -
9/4/79 1:12 pm	slow	22	2860	3.02	688	0.0		
9/10/79 1:25 pm	slow	19	3020	3.02	932	0.0		
9/17/79 2:25 pm	medium	20.5	3060	3.04	924	0.0		
9/24/79 12:40 pm	slow	11	2900	2.98	954	0.0	1940	- -
10/1/79 12:42 pm	slow	18	2710	3.10	1590	0.0		- -
10/9/79 10:18 pm	slow	14	2820	2.82	966	0.0		- -
10/15/79 1:34	slow	9.5	2810	3.02	874	0.0		- -
10/23/79 12:05	slow	13	2590	3.35		0.0		- -
10/29/79 1:50	very slow	12.5	2450	3.42	590	0.0	1900	- -
11/5/79 1:30	slow	10	2720	3.40	596	0.0		
11/12/79 1:10	very slow	8	2650	3.65	547	0.0		- -
11/18/79 1:00	very slow	10	3190	3.12	914	0.0		- -
11/26/79 1:16	slow	11	2440	3.35	610	0.0	1775	- T
12/3/79 2:13	slow	3	2480	3.76	506	0.0		- -
12/10/79 1:05	slow	4	2460	3.68	514	0.0		

Bedway Site, Fairview, Ohio
Sample Location # 1 (cont.)

Date & Time of Collection	Q	Temp. °C	S. Cond. umho/cm	pH	Acidity mg/l as $CaCO_3$	Alkalinity mg/l as $CaCO_3$	Sulfate mg/l	Tracer $Br^-F^-I^-$
12/17/79 12:30	frozen							
12/24/79 10:43	slow	8.5	1950	3.75	433	0.0	1850	- -
1/2/80	frozen-no flow							
1/8/80	frozen-no flow							
1/14/80 12:42	slow	3.0	2370	3.75	387	0.0		
1/22/80 5:03	slow	2.0		3.55	574	0.0		- -
2/1/80 2:45 pm	frozen							
2/4/80 11:30 am	frozen							
2/11/81 11:20 am	frozen							
2/19/80 4:15 pm	medium	1.0	448	3.80	48	0.0		
2/25/80 12:05 pm	dry							
3/3/80 10:50 am	frozen							
3/10/80 11:25 am	very slow	3.0	2490	3.40	473	0.0		- -
3/17/80 11:33 am	slow	4.0	2320	3.55	436	0.0		- -
3/23/80 1:58 pm	very slow	6.0	2300	3.40	433	0.0		
3/31/80 1:55 pm	slow	8.5	2520	3.45	499	0.0	1925	
4/7/80 1:25 pm	very slow	8.0	2670	3.38	556	0.0		
4/14/80 3:10 pm	slow	9.5	1600	3.52	376	0.0		
4/21/80 12:07 pm	very slow	13	2810	3.57	940	0.0		
4/28/80 12:08 pm	slow	10.5	2820	3.35	641	0.0	2350	
5/5/80 12:35 pm	very slow	15	2900	3.22	773	0.0		-
5/12/80 1:40 pm	very slow	14	3090	3.20	928	0.0		- -
5/19/80 2:20 pm	slow	15	2640	3.22	603	0.0		- -
5/29/80 1:10 pm	very slow	16	3000	3.11	777	0.0	2200	- -
6/3/80 12:40	slow	19	2730	3.23	774	0.0		- -
6/9/80 12:18 pm	very slow	14	2790	3.12	689	0.0		- -
6/18/80 12:10 pm	very slow	15	3010	3.13	740	0.0		- -
6/24/80 7:12	very slow	17	3720	2.90	990	0.0	2500	- -
7/3/80 4:05 pm	very slow	20.5	3320	3.16	795	0.0		- -
7/9/80 9:42 am	very slow	18.5	3180	3.01	744	0.0		- -
7/15/80	dry							

Bedway Site, Fairview, Ohio
Sample Location # 1 (cont.)

Date & Time of Collection	Q	Temp. ^oC	S. Cond. umho/cm	pH	Acidity mg/l as $CaCO_3$	Alkalinity mg/l as $CaCO_3$	Sulfate mg/l	Tracer $Br^-F^-I^-$
7/25/80 7:10	very slow	21	2890	3.50	406	0.0		- -
8/8/80 9:40	slow	20	2790	3.50	420	0.0	1840	- -
8/14/80 7:43	slow	21.5	2450	3.60	376	0.0		- -
8/22/80 11:38	very slow		2670	3.39	519	0.0		- -
8/28/80 2:50	very slow	22	3010	3.30	604	0.0		- -
9/7/80 8:10	very slow	17.5	3040	3.39	665	0.0	2330	- -
9/16/80 3:43	very slow		3240	3.41	731	0.0		- -
9/22/80 2:25	very slow	20	3240	3.28	749	0.0		- -
10/1/80 1:10	very slow	16	3320	3.22	766	0.0	2500	- -
10/6/80 1:08	very slow	11	3260	3.32	751	0.0		- -
10/15/80 11:38	very slow	11	3280	3.33	660	0.0		- -
10/20/80 2:10	very slow	10	2940	3.31	701	0.0		- -
10/27/80 3:15	very slow	10	2680	3.35	621	0.0	2300	- -
11/3/80 12:55	very slow	10	2790	3.40	604	0.0		- T
11/10/80 12:39	very slow	7.5	2880	3.34	586	0.0		- -
11/19/80 2:05	very slow	4.5	2730	3.44	541	0.0		- -
11/24/80 12:45	very slow	7.0	2520	3.30	569	0.0		- -
12/1/80 1:00	very slow	7.0	2620	3.37	472	0.0	2000	- -
12/8/80 12:40	very slow	10	2580	3.40	454	0.0		- -
12/22/80	frozen							
12/29/80	frozen							
1/6/81	frozen							
1/19/81	frozen							
1/26/81 12:22	very slow		2420	3.32	460	0.0	1880	- -
2/13/81	frozen							
2/17/81 3:08	very slow	2.0	1600	3.63	226	0.0		- T
2/25/81 3:55	very slow	3.0	1850	3.59	312	0.0	1520	- T
3/4/81 3:14	very slow	3.0	2270	3.51	422	0.0		- -
3/11/81 12:30	very slow	4.0	2100	3.63	374	0.0		- -
3/16/81 1:42	very slow	.5	2500	3.62	458	0.0		- -

Bedway Site, Fairview, Ohio
Sample Location # 1 (cont.)

Date & Time of Collection		Q	Temp. ^{o}C	S. Cond. umho/cm	pH	Acidity mg/l as $CaCO_3$	Alkalinity mg/l as $CaCO_3$	Sulfate mg/l	Tracer $Br^{-}F^{-}I^{-}$
3/23/81	1:40	very slow	7.0	2600	3.65	488	0.0	1900	- -
4/3/81	4:08	very slow		2450	3.61	423	0.0		- -
4/19/81	11:09	slow	10	2150	3.58	502	0.0		- -
4/25/81	12:08	very slow	9	2800	3.55	546	0.0	2030	- -
5/1/81	6:15	very slow	11.5	2520	3.57	594	0.0		- -
5/9/81	7:08	very slow		2600	3.50	646	0.0		- -
5/15/81	10:38	very slow		2450	3.38	626	0.0		- -
5/24/81	12:00	very slow	15.0	2810	3.40	657	0.0		- -
5/31/81	11:45	very slow	15.0	2500	3.42	572	0.0		- -
6/7/81	11:09	slow	15.0	2380	3.48	477	0.0		- -
6/16/81	10:11	slow	18.0	2200	3.53	490	0.0		- -
6/26/81	6:05	slow	19.0	2020	3.85	395	0.0		- -
7/7/81	5:28	slow	23.5	2700	3.41	707	0.0		- -
7/15/81	7:05	very slow	20.5	2900	3.32	800	0.0		- -
7/22/81	7:05	very slow	21.5	2950	3.45	770	0.0		- -
7/29/81	9:30	slow	18.0	2450	3.50	541	0.0		- -
8/4/81	8:09	slow	19.0	2500	3.29	562	010		- -

Bedway Site, Fairview, Ohio
Sample Location # 2

Date & Time of Collection	Q	Temp. °C	S. Cond. umho/cm	pH	Acidity mg/l as $CaCO_3$	Alkalinity mg/l as $CaCO_3$	Sulfate mg/l	Tracer $Br^-F^-I^-$
11/17/78 12 pm	3 gpm	12.4	4400	2.5	2125	0.0	4290	-
4/2/79	0.25 cfs	11.3	4200	2.4	2202	0.0	4800	-
6/13/79 11 am	0.3 cfs	12.0	5050	2.50	4579	0.0		
6/16/79 12:15 pm	0.7 cfs	11.5	5020	2.50	2310			
6/22/79 1:15 pm		11.0	5020	2.60	2320			
6/29/79 1:03 pm	moderate	11.5	5000	2.62		0.0	4440	- - -
7/7/79 5:35 pm	.2 cfs	12	4910	2.55	2405	0.0		
7/14/79 4:30 pm	.2 cfs	12	3810	2.75	2390	0.0		
7/23/79 1:05 pm	slow	12	5250	2.53	2120	0.0		
7/30/79 12:00 pm	medium	12.5	4910	2.58	1910	0.0	4000	- -
8/6/79 12:10 pm	medium	13	5000	2.65	2040	0.0		-
8/13/79 12:10 pm	medium	10	4510	2.40	1950	0.0		-
8/22/79 1:10 pm	medium fast	11.5	4520	2.55	1920	0.0		
8/28/79 1:10 pm	good	13	4480	2.60	2050	0.0	3650	-
9/4/79 1:05 pm	good	13	4620	2.45	2250	0.0		
9/10/79 1:20 pm	fast	13	4690	2.50	2280	0.0		
9/17/79 2:19 pm	good	14	4720	2.52	2180	0.0		
9/24/79 12:30 pm	fast	13	4490	2.54	2170	0.0	3750	- -
10/1/79 12:35 pm	fast	13.5	4320	2.68	2120	0.0		-
10/9/79 10:15 pm	medium fast	14	4360	2.60	2000	0.0		- -
10/15/79 1:32	slow	13	4380	2.67	1925	0.0		- -
10/23/79 12:01	medium	13	4440	2.68	2140	0.0		- -
10/29/79 1:45	medium fast	13	4060	2.90	1885	0.0	3750	- -
11/5/79 1:25	medium fast	13	4640	2.75	2040	0.0		-
11/12/79 1:00	medium fast	13	4660	3.00	1960	0.0		- - -
11/18/79 1:10	medium	13	4700	2.71	2110	0.0		- -
11/26/79 1:12	medium	13	4690	2.68	1920	0.0	3810	- -
12/3/79 2:10	medium	12	4460	2.80	1880	0.0		- -
12/10/79 1:00	medium fast	12	4440	2.68	1795	0.0		
12/17/79 12:31	medium fast	5	4460	2.58	1370	0.0		-

Bedway Site, Fairview, Ohio
Sample Location # 2 (cont.)

Date & Time of Collection		Q	Temp. ^{o}C	S. Cond. umho/cm	pH	Acidity mg/l as $CaCO_3$	Alkalinity mg/l as $CaCO_3$	Sulfate mg/l	Tracer $Br^-F^-I^-$
12/24/79	10:40	medium	13	3610	2.55	1700	0.0	3600	- - -
1/2/80	10:45	medium	12	3350	2.55	1700	0.0		
1/8/80	3:08	medium	11.5	4700	2.68	1750	0.0		
1/14/80	12:39	fast	12.0	4610	2.70	1695	0.0		
1/22/80	5:10	good	11.0		2.90	1760	0.0		-
2/1/80	2:45	good	10	4320	2.90	1790	0.0		- -
2/4/80	11:45 am	good	11.0	4620	2.88	1815	0.0		- -
2/11/80	11:25	good	11.0	4580	2.60	1755	0.0		-
2/19/80	4:20 pm	good	12.0	4650	3.04	1620	0.0		
2/25/80	12:10	good	11.0	4200	2.70	1375	0.0	3150	- -
3/3/80	10:50	good	10.0	4450	2.69	1655	0.0		
3/10/80	11:25	good	11.0	4420	2.68	1545	0.0		- -
3/17/80	11:20	good	10.0	4450	2.77	1900	0.0		- -
3/23/80	1:50 pm	good	11.0	4270	2.65	1575	0.0		
3/31/80	1:50 pm	good	11.0	4650	2.80	1920	0.0	3725	- -
4/7/80	1:18 pm	good	11.0	4510	2.71	1920	0.0		
4/14/80	3:05 pm	fast	10.0	3930	2.70	1785	0.0		
4/21/80	12:05 pm	good	11	4530	2.68		0.0		
4/28/80	12:05 pm	med. good	11.0	4480	2.65	1855	0.0	3850	
5/5/80	12:33 pm	med. fast	11.0	4430	2.59	1945	0.0		-
5/12/80	1:35	fast	11.0	4600	2.60	1955	0.0		- -
5/19/80	2:14	fast	11.0	4290	2.64	1828	0.0		- -
5/29/80	1:05	fast	12.0	4420	2.60	1955	0.0	3380	- -
6/3/80	12:33	fast	11.0	4080	2.59	1707	0.0		- -
6/9/80	12:12	fast	11.0	4210	2.63	1851	0.0		- -
6/18/80	12:05	fast	11	4530	2.70	1840	0.0		- -
6/24/80	7:08	fast	11.3	4810	2.72	1665	0.0	3270	- -
7/3/80	4:03	fast	12	4800	2.70	1810	0.0		- -
7/9/80	9:35	fast	12.5	4730	2.53	1866	0.0		- -
7/15/80	2:03	fast	12	4750	2.68	1710	0.0		- -
7/25/80	7:05	fast	13	4380	2.69	1475	0.0		- -

Bedway Site, Fairview, Ohio
Sample Location # 2 (cont.)

Date & Time of Collection		Q	Temp. ^{o}C	S. Cond. umho/cm	pH	Acidity mg/l as $CaCO_3$	Alkalinity mg/l as $CaCO_3$	Sulfate mg/l	Tracer Br$^-$F$^-$I$^-$
8/8/80	9:35	fast	13	4500	2.70	1631	0.0	3320	- -
8/14/80	7:35	fast	14	4590	2.64	1836	0.0		- -
8/22/80	11:35	fast		4460	2.70	1811	0.0		- -
8/28/80	2:35	fast	15	4530	2.64	1739	0.0		- - -
9/7/80	8:00	fast	14		2.70	1858	0.0	3240	- - -
9/16/80	3:35	fast		4320	2.73	1434	0.0		- - -
9/22/80	2:30	med. fast	13.5	4320	2.67	1628	0.0		- - -
10/1/80	1:00	medium	13.5	4400	2.64	1566	0.0	3250	- - -
10/6/80	1:05	medium	13	4420	2.70	1500	0.0		- - -
10/15/80	11:35	med. fast	12	4500	2.65	1659	0.0		- - -
10/20/80	2:20	med. fast	13	4110	2.66	1513	0.0		- - -
10/27/80	3:20	medium	12.5	3820	2.67	1508	0.0	3375	- - T
11/3/80	12:45	medium	13	4020	2.67	1602	0.0		- - -
11/10/80	12:30	medium	12	4210	2.60	1620	0.0		- - -
11/19/80	2:00	medium	12	4210	2.63	1557	0.0		- - -
11/24/80	12:30	slow	12	3500	2.59	1558	0.0		- - -
12/1/80	12:45	medium	12	4100	2.60	1609	0.0	3190	- - -
12/8/80	12:30	med. slow	12	4060	2.61	1515	0.0		- - -
12/22/80	1:20	med. slow	11	3810	2.60	1447	0.0		- -
12/29/80	12:30	medium	11	3880	2.66	1499	0.0	3210	- -
1/6/81	4:20	slow	10	2520	2.64	1741	0.0		- -
1/19/81	12:30	med. slow	9.5	4125		1340	0.0		- -
1/26/81	12:15	med. slow		3960	2.58	1620	0.0	3320	- -
2/13/81	12:30	medium		3200	2.65	1205	0.0		- -
2/17/81	3:00	medium	10	3370	2.68	1105	0.0		- -
2/25/81	3:42	med. fast	10	3400	2.70	1350	0.0	2850	- -
3/4/81	3:10	med. fast	10.5	3670	2.68	1420	0.0		- -
3/11/81	12:20	medium	10.5	3800	2.68	1215	0.0		- -
3/16/81	1:35	medium	10	4040	2.62	1320	0.0		- -
3/23/81	1:35	medium	10	4140	2.61	1355	0.0	3175	- -

Bedway Site, Fairview, Ohio
Sample Location # 2 (cont.)

Date & Time of Collection		Q	Temp. °C	S. Cond. umho/cm	pH	Acidity mg/l as $CaCO_3$	Alkalinity mg/l as $CaCO_3$	Sulfate mg/l	Tracer $Br^-F^-I^-$
4/3/81	4:00	medium	11	3800	2.64	1365	0.0		- -
4/19/81	11:05 am	fast	11	3820	2.61	1925	0.0		- -
4/25/81	12:05	medium	10.5	3860	2.50	2095	0.0	3550	- -
5/1/81	6:09	fast	10.5	3780	2.85	1670	0.0		- -
5/9/81	7:05	med. fast		3850	2.68	1680	0.0		- -
5/15/81	10:35	med. fast		3900	2.65	1621	0.0		- -
5/24/81	11:50	medium	11.0	4000	2.62	1488	0.0		- -
5/31/81	11:40	fast	11.0	3700	2.70	1377	0.0		- -
6/7/81	11:05	fast	11.0	3700	2.70	1417	0.0		- -
6/16/81	10:04	med. fast	11.5	3400	2.82	1460	0.0		- -
6/26/81	6:03	med. fast	12.0	3350	3.10	1248	0.0		- -
7/7/81	5:20	medium	12.0	3900	2.78	1690	0.0		- -
7/15/81	7:00	medium	12.0	4090	2.60	1690	0.0		- -
7/22/81	7:00	med. fast	12.5	4050	2.68	1677	0.0		- -
7/29/81	9:25	fast	13.0	3780	2.80	1378	0.0		- -
8/4/81	8:04	med. fast	12.0	3820	2.88	1456	0.0		- -

Bedway Site, Fairview, Ohio
Sample Location # 3

Date & Time of Collection	Q	Temp. ^oC	S. Cond. umho/cm	pH	Acidity mg/l as $CaCO_3$	Alkalinity mg/l as $CaCO_3$	Sulfate mg/l	Tracer $Br^-F^-I^-$
4/2/79 4 pm	trickle	13	2000	4.7	62	11.0	2156	- -
6/13/79	0.01 cfs	15	2700	6.72	0			
6/16/79 12:30 pm	0.02 cfs	19	2550	6.25	0	104.5		
6/22/79 1:25 pm		16	2580	7.5	0	134		
6/29/79 1:00 pm	small	16		7.5	0	165	1620	- -
7/7/79 5:30 pm	very low	15	2500	7.2		154		
7/14/79 4:25 pm	very low	21	2590	7.5		170		
7/23/79 1:00 pm	very slow	20		7.9		143		
7/30/79 11:30	slow	20	2500	7.2		138	1575	-
8/6/79 12:00	very slow	23	2620	7.1 (field)	0	93.5		-
				5.72 (lab)				
8/13/79 12:00	slow	14.5	2490	7.4	0	132		
8/22/79 1:00	medium slow	18	2420	7.4 (field)	0	165		
				6.08 (lab)				
8/28/79 1:00	medium slow	12	3100	2.09	578	0	2170	- -
9/4/79 1:00	medium slow	17	2700	3.38	346	0		
9/10/79 1:15	slow	15	2440	4.8	39	5.5		
9/17/79 2:17	medium flow	14	2410	5.75	0	132.0		
9/24/79 12:35	slow	12.5	2410	7.7	0	126.5	1980	-
10/1/79 10:10	medium	15	2310	8.2	2.86	121		-
10/9/79 10:10	medium	13	2340	7.1	0	152		-
10/15/79 1:22 pm	slow	9	2340	7.9	0	141		- -
10/23/79 11:54 pm	very slow	12.5	2320	7.3	0	148		- T
10/29/79 1:30 pm	very slow	10	2200	7.5	0	170	1575	- T
11/5/79 1:19 pm	very slow	8	2420	7.8	0	170		
11/12/79 12:58 pm	very slow	5.5	2380	7.3	0	158		- T
11/18/79 1:15	very slow	8	2480	8.0	0	128		- T
11/26/79 1:04	slow	10	2380	7.8	0	163	1445	- T
12/3/79 2:00	slow	2	2360	7.7	0	190		- T
12/10/79 12:45	very slow	4	2350	8.3	0	192		

Bedway Site, Fairview, Ohio
Sample Location # 3 (cont.)

Date & Time of Collection		Q	Temp. °C	S. Cond. umho/cm	pH	Acidity mg/l as $CaCO_3$	Alkalinity mg/l as $CaCO_3$	Sulfate mg/l	Tracer $Br^-F^-I^-$
12/17/79		frozen-no flow							
12/24/79	10:30 am	slow	6.5	2010	8.0	0	214	1270	
1/2/80	10:35 am	very slow	2	1780	8.1	2	265		
1/8/80	3:00 pm	frozen							
1/14/80	12:36 pm	medium	5.0	2610	4.3	192	0		
1/22/80	5:16 pm	slow	2.0		5.4	5	29		
2/1/80	2:45 pm	frozen							
2/4/80	11:30 am	frozen							
2/11/80	11:30	frozen							
2/19/80	4:20 pm	frozen							
2/25/80	12:15	very slow	2.0	2390	4.32	120	0		
3/3/80	10:50	frozen							
3/10/80	11:15	very slow	3.0	2580	6.5	120	41		
3/17/80	11:30	slow	6.0	2920	3.0	588	0		
3/23/80	1:55 pm	medium	9.0	3430	2.95	930	0		
3/31/80	1:53 pm	med. slow	10.5	3700	3.00	1078	0	2700	
4/7/80	1:20 pm	medium	10.5	3720	3.00	1178	0		
4/14/80	3:00 pm	fast	10.0	3850	2.71	502	0		
4/21/80	12:00	slow	13	3810	2.90	1134	0		
4/28/80	12:03 pm	slow	12.0	3630	2.90	1068	0	2760	
5/5/80	12:30	very slow	16.0	3330	2.90	837	0		-
5/12/80	1:30	very slow	15.0	2810	3.49	355	0		- -
5/19/80	2:10	med. slow	14.0	3420	2.90	1000	0		- -
5/29/80	1:00	slow	18	3660	2.80	1150	0	2600	- -
6/3/80	12:30	medium	14	3440	2.78	1136	0		- -
6/9/80	12:08	slow	14	3700	2.79	1376	0		- -
6/18/80	12:00	med. slow	15	4090	2.78	1545	0		- -
6/24/80	7:05	slow	14	4230	2.89	1196	0	2850	- -
7/3/80	4:00	very slow	18.5	3610	3.04	810	0		- -
7/9/80	9:30	slow	17	3690	2.78	996	0		- -
7/15/80	2:00	very slow	20	3390	3.08	649	0		- -
7/25/80	7:00	slow	17	2490	7.70	10	110		- -

Bedway Site, Fairview, Ohio
Sample Location # 3 (cont.)

Date & Time of Collection		Q	Temp. °C	S. Cond. umho/cm	pH	Acidity mg/l as $CaCO_3$	Alkalinity mg/l as $CaCO_3$	Sulfate mg/l	Tracer $Br^-F^-I^-$
8/8/80	9:30	slow	17	2450	7.74	0	105	1320	- -
8/14/80	7:30	slow	16	2230	6.02	3	19		- -
8/22/80	11:36	slow		2380	6.89	0	64		- -
8/28/80	2:30	very slow	17	2490	6.94	0	79		- -
9/7/80	8:05	very slow	16	1210	6.32	0	22	1480	- -
9/16/80	3:30	very slow		1290	7.32	0	107		- -
9/22/80	stagnant	dry							
10/1/80		dry							
10/6/80	1:00	very slow	9.5	1230	4.79		2		- -
10/15/80	11:30	very slow	11	1250	4.75	19	5		- -
10/20/80	stagnant								
10/27/80		dry							
11/3/80	stagnant								
11/10/80		dry							
11/19/80		dry							
11/24/80		dry							
12/1/80		dry							
12/8/80		dry							
12/22/80		frozen							
12/29/80		frozen							
1/6/81		frozen							
1/19/81		frozen							
1/26/81		dry							
2/13/81		frozen							
2/17/81		dry							
2/25/81	3:35	very slow	4.0	1710	7.15	0	108	1060	- -
3/4/81	3:05	very slow	2.0	1970	6.65	1.6	118		- T
3/11/81	12:15	very slow	4.0	2090	6.50	0	68		- T
3/16/81		dry							
3/23/81		dry							

Bedway Site, Fairview, Ohio
Sample Location # 3 (cont.)

Date & Time of Collection	Q	Temp. °C	S. Cond. umho/cm	pH	Acidity mg/l as $CaCO_3$	Alkalinity mg/l as $CaCO_3$	Sulfate mg/l	Tracer $Br^-F^-I^-$
4/3/81	dry							
4/19/81 11:00 am	slow	10.0	1920	6.80	0	84		– –
4/25/81 12:00	slow	9.0	2040	6.60	0	76	1400	– –
5/1/81 6:05	slow	10.0	2100	7.10	0	95		– –
5/9/81 7:00	very slow		2160	6.60	0	89		– T
6/15/81 10:30	very slow		2000	2.90				
5/24/81	dry							
5/31/81	very slow	17.0	2050	7.05	0	90		
6/7/81	lsow	15.0	2100	7.12	0	104		
6/16/81 10:00	slow	15.5	1900	7.30	0	85		– T
6/26/81 6:00	slow	14.0	1830	7.20	0	79		– T
7/7/81 5:15	slow	17.0	2120	6.60	29	71		
7/15/81	dry							
7/22/81	dry							
7/29/81 9:20	slow	21.5	2190	7.70	0	10		– –
8/4/81 8:00	very slow	18.0	2050	7.03	10	86		– –
8/12/81	dry							
8/20/81	dry							
8/27/81	dry							
9/1/81	dry							
9/9/81	dry							
9/17/81	dry							
9/23/81	dry							
9/30/81	dry							

Bedway Site, Fairview, Ohio
Sample Location # 4

Date & Time of Collection	Q	Temp. ^oC	S. Cond. umho/cm	pH	Acidity mg/l as $CaCO_3$	Alkalinity mg/l as $CaCO_3$	Sulfate mg/l	Tracer $Br^-F^-I^-$
4/2/79	0.08 cfs	11.7	2880	3.10				
6/13/79	low	15	3420	3.20	896	0		- -
6/16/79 12:30 pm	low	16.5	4400	3.20	907	0		
6/22/79 1:30		16	3320	3.21	3270	0		
6/29/79 1:15	low	11	3390	2.3	953	0	2650	- -
7/7/79 5:45 pm	very low	16	3230	3.30	1100	0		
7/14/79 4:35 pm	very low	19	3200	3.55	1014			
7/23/79 1:15	very slow	18.3	3410	3.31	915			
7/30/79 12:20	slow	19	3180	3.22	922		3510	- -
8/6/79 12:15	very slow	20	3310	3.26	1100			
8/13/79 12:20	slow	15	2910	3.15	701	0		
8/22/79 1:15	slow	17	2900	3.30	730	0		
8/28/79 1:15	slow	19	2860	3.22	682	0	2125	
9/4/79 1:10	slow	19	2980	3.10	826			
9/10/79 1:25	slow	17	3020	3.20	869			
9/17/79 2:29	slow	17	3010	3.18	869			
9/24/79 12:43	slow	15	2920	3.20	908			
10/1/79 12:48	slow	11	2850	3.20	875			- -
10/9/79 10:24	slow	13	2920	3.25	850			- -
10/15/79 1:38	slow	10.5	3010	3.30	958	0		- -
10/23/79 12:10	slow	13	3060	3.30	893	0		- -
10/29/79 1:55	very slow	12	2810	3.45	811	0	2700	- -
11/5/79 1:40	slow	11	3110	3.40	871	0		
11/12/79 1:14	very slow	9.5	3090	3.50	858	0		- -
11/18/79 1:18	very slow	10	3190	3.40	847	0		- -
11/26/79 1:19	slow	11	2980	3.40	693	0	2300	- T
12/3/79 2:20	slow	6	2940	3.65	724	0		- -
12/10/79 1:10	slow	6	2880	3.58	725	0		
12/17/79	frozen-no flow							
12/24/79 10:47 am	slow	7.0	2050	3.51	618	0	2190	

Bedway Site, Fairview, Ohio
Sample Location # 4 (cont.)

Date & Time of Collection		Q	Temp. °C	S. Cond. umho/cm	pH	Acidity mg/l as $CaCO_3$	Alkalinity mg/l as $CaCO_3$	Sulfate mg/l	Tracer $Br^-F^-I^-$
1/2/80	10:40 am	frozen-no flow							
1/8/80	3:00 pm	frozen							
1/14/80	12:48	slow	4.0	2800	3.62	524	0		- -
1/22/80	4:55	very slow	8.5		3.77	564			
2/1/80	2:45 pm	frozen							
2/4/80		frozen							
2/11/80		frozen							
2/19/80		frozen							
2/25/80		dry							
3/3/80		frozen							
3/10/80		dry							
3/17/80	11:35	slow	5.0	2610	3.68	404	0		
3/23/80	2:03 pm	very slow	7.5	2600	3.55	504	0		
3/31/80	1:58 pm	slow	9.0	2850	3.58	638	0	2285	
4/7/80	1:28	very slow	8.5	2910	3.50	1182	0		
4/14/80	3:10	slow	9.5	2450	3.48	654	0		
4/21/80	12:10	very slow	12	3100	3.50	852	0		
4/28/80	12:10	slow	11.0	3100	3.40	788	0	2700	
5/5/80	12:37	very slow	14.0	3080	3.33	772	0		-
5/12/80	1:43	very slow	12.0	3110	3.42	754	0		- -
5/19/80	2:17	slow	14.0	2900	3.37	714	0		- -
5/29/80	1:15	very slow	15.0	3100	3.34	810	0	2375	- -
6/3/80	12:44	slow	16	2430	3.15	554	0		- -
6/9/80	12:15	very slow	15	2930	3.31	762	0		- -
6/18/80	12:13	very slow	14	3160	3.49	762	0		- -
6/24/80	7:13	very slow	15	3310	3.52	631	0	2125	- -
7/3/80	4:08	dry							
7/9/80	9:38	very slow	17.5	3120	3.28	681	0		- -
7/15/80		dry							
7/25/80		dry							
8/8/80	9:43	slow	18	3220	3.29	673	0	2350	- -

Bedway Site, Fairview, Ohio
Sample Location # 4 (cont.)

Date & Time of Collection		Q	Temp. ^oC	S. Cond. umho/cm	pH	Acidity mg/l as $CaCO_3$	Alkalinity mg/l as $CaCO_3$	Sulfate mg/l	Tracer $Br^-F^-I^-$
8/14/80	7:40	slow	18	3090	3.17	739	0		- -
8/22/80	11:40	very slow		3220	3.13	811	0		- -
8/28/80	2:45	slow	20	3480	3.03	881	0		- -
9/7/80	8:13	slow	17		3.13	883	0	2480	- -
9/16/80	3:40	very slow		3520	3.18	871	0		- -
9/22/80	2:20	very slow	19	3420	3.16	865	0		- -
10/1/80		dry							
10/6/80		dry							
10/15/80		dry							
10/20/80		dry							
10/27/80		dry							
11/3/80		dry							
11/10/80		dry							
11/19/80		dry							
11/24/80		dry							
12/1/80		dry							
12/8/80		dry							
12/22/80		dry							
12/29/80		dry							
1/6/81		frozen							
1/19/81		frozen							
1/26/81		dry							
2/13/81		frozen							
2/17/81	3:13	med. slow	6.0	1460	3.88	152	0		- -
2/25/81	4:00	slow	5.0	2000	3.75	348	0	1530	- -
3/4/81	3:19	very slow	4.5	2390	3.70	464	0		- -
3/11/81	12:33	very slow	6.0	2500	3.70	412	0		T -
3/16/81	1:45	very slow	6.0	2640	3.67	424	0		- -
3/23/81		dry							
4/3/81		dry							

Bedway Site, Fairview, Ohio
Sample Location # 4 (cont.)

Date & Time of Collection		Q	Temp. °C	S. Cond. umho/cm	pH	Acidity mg/l as $CaCO_3$	Alkalinity mg/l as $CaCO_3$	Sulfate mg/l	Tracer $Br^-F^-I^-$
4/19/81	11:14 am	medium	10.0	2410	3.50	570	0		- -
4/25/81	12:13	slow	9.0	2320	3.38	792	0	2050	- -
5/1/81	6:19	slow	11.0	2740	3.50	722	0		- -
5/9/81	7:10	very slow		2850	3.45	748	0		- -
5/15/81	10:44	med. slow		2900	3.38	736	0		- -
5/24/81	12:04	very slow	16.0	3000	3.30	739	0		- -
5/31/81	11:48	slow	16.0	2300	3.40	652	0		- -
6/7/81	11:11	med. slow	14.0	2710	3.45	642	0		- -
6/16/81	10:08	med. slow	16.5	2500	3.40	677	0		- -
6/26/81	6:08	med. slow	16.0	2400	3.62	582	0		- -
7/7/81	5:24	slow	19.0	2950	3.27	884	0		- -
7/15/81	7:08	slow	18.0	3110	3.20	832	0		- -
7/22/81	7:08	slow	19.0	3100	3.27	780	0		- -
7/29/81	9:34	medium	12.0	2700	3.43	676	0		- -
8/4/81	8:13	medium	17.0	2780	3.48	686	0		- -
8/12/81	6:12	very slow							

Bedway Site, Fairview, Ohio
Sample Location # 5

Date & Time of Collection	Q	Temp. °C	S. Cond. umho/cm	pH	Acidity mg/l as $CaCO_3$	Alkalinity mg/l as $CaCO_3$	Sulfate mg/l	Tracer Br-F-I-
11/17/78 1 pm	0.1 cfs	12.1	3400	2.7	1186	0	3010	- -
4/2/79 2 pm	0.3 cfs	10.1	2850	2.6	985	0	2825	- -
6/13/79		12.2	3710	2.73	906	0		
6/16/79 1:10		12	3650	2.70	901	0		
6/22/79 2:05		11.5	3600	2.80	934	0		
6/29/79 5:45		11	2600	2.80	938	0	2625	
7/7/79 4:15		12	3610	2.78	956			
7/16/79 5:45		11	3510	3.10	1010	0		
7/23/79 4:20	good flow	11	3800	2.75	898	0		
7/30/79 4:20	good	10	3810	2.70	1026	0	2660	- -
8/6/79 2:50	fast		3690	2.78	826	0		
8/13/79 3:40	good	10	3210	2.80	699	0		
8/22/79 3:25	good	9	3100	2.88	624	0		
8/28/79 3:20	good	13	3080	2.82	555	0	1850	- -
9/4/79 1:10	good	13	3060	2.78	622	0		
9/10/79 2:54	good	13	3040	2.80	677	0		
9/17/79 3:43	good	13	3040	2.86	675	0		
9/24/79 1:45	good	13	2980	2.82	691	0	2200	- -
10/1/79 2:05	good	13	2840	2.92	618	0		
10/9/79 11:22	fast	12.5	2820	2.92	630	0		-
10/15/79 1:30	fast	13	2820	2.95	605	0		- -
10/23/79 11:25	good	13.5	2800	2.98	568	0		- -
10/29/79 1:25	good	12	2580	3.12	536	0	2060	- -
11/5/79 1:30	fast	12	2900	3.02	578	0		
11/12/79 1:30	good	12	2960	3.15	602	0		- -
11/18/79 3:45	good	12.5	3000	2.98	584	0		- -
11/26/79 2:05	good	11.5	3020	2.96	597	0	2100	- T
12/3/79 1:50	good	11.5	2950	3.12	589	0		- -
12/10/79 2:15	good	10.5	2900	3.02	580	0		
12/17/79 2:40	good	10	2980	2.90	573	0		

Bedway Site, Fairview, Ohio
Sample Location # 5 (cont.)

Date & Time of Collection	Q	Temp. oC	S. Cond. umho/cm	pH	Acidity mg/l as $CaCO_3$	Alkalinity mg/l as $CaCO_3$	Sulfate mg/l	Tracer $Br^-F^-I^-$
12/24/79 12:40	good	11	2180	2.90	536	0	2150	- -
1/2/80 12:55	good	11	2350	2.80	556	0		
1/8/80 4:25	good	11	3210	2.95	556	0		
1/14/80 1:00	fast	12.0	3280	3.00	610	0		
1/22/80 5:35 pm	good	10.5		3.15	604	0	2175	- -
2/1/80 3:20	good	9.5	3080	3.21	598	0		- -
2/4/80 11:40 am	good	10.0	3420	3.15	608	0		- -
2/11/80 11:50	good	10.0						
2/19/80 4:35	good	10.0	3120	3.05	534	0		
2/25/80 12:30	good	10.0	3050	3.0	580	0		
3/3/80 11:20	good	8.0	3250	3.0	572	0		
3/10/80 11:45	good	9.0	3050	3.0	546	0		
3/17/80 11:50	good	9.0	3.30	3.02	600	0		
3/23/80 2:15 pm	good	10	3200	2.90	642	0		
3/31/80 2:10 pm	good	10	3340	2.99	740	0	2425	- -
4/7/80 1:40 pm	good	10	3210	3.45	1022	0		
4/14/80 3:20 pm	fast		2990	2.87	712	0		
4/21/80 12:25	good	10.5	3270	2.99	756	0		
4/28/80 12:25	good	11	3190	2.94	704	0	2325	- -
5/5/80 12:55	fast	11	3100	2.90	710	0		-
5/12/80 1:55	fast	10	3200	2.92	689	0		- -
5/19/80 2:34	fast	10.5	3090	2.95	686	0		- -
5/29/80 1:30	fast	10.5	3150	2.89	750	0	2150	- -
6/3/80 1:00	fast	11	3040	2.83	700	0		- -
6/9/80 12:30	fast	10.5	2970	2.91	672	0		- -
6/18/80 12:20	fast	10.5	3140	3.07	634	0		- -
6/24/80 6:50	fast	12	3340	3.07	567	0	2040	- -
7/3/80 4:30	fast	12	3290	3.02	646	0		- -
7/9/80 9:55	fast	11.5	3300	2.79	602	0		- -
7/15/80 2:14	fast	11	3390	2.79	562	0		- -
7/25/80 7:25	fast	12	3380	3.03	451	0		- -
8/8/80 9:55	fast	12	2980	3.05	451	0	1870	- -

Bedway Site, Fairview, Ohio
Sample Location # 5 (cont.)

Date & Time of Collection	Q	Temp. °C	S. Cond. umho/cm	pH	Acidity mg/l as $CaCO_3$	Alkalinity mg/l as $CaCO_3$	Sulfate mg/l	Tracer $Br^-F^-I^-$
8/14/80 8:00	fast		3220	2.91	663	0		- -
8/22/80 11:58	fast		3070	3.00	594	0		- -
8/28/80 3:10	fast	13	3120	2.90	595	0		- -
9/7/80 8:30 pm	fast	14	3180	2.98	606	0	2060	- -
9/16/80 3:55	fast		3200	3.00	566	0		- -
9/22/80 1:58	fast	13	3200	2.95	593	0		- -
10/1/80 1:40	medium	13	3220	2.90	564	0		- -
10/6/80 1:25	med. fast	13	3240	2.96	566	0	2050	- -
10/15/80 11:58	med. fast	12	3240	2.94	506	0		- -
10/20/80 1:45	fast	13	2980	2.94	491	0		- -
10/27/80 2:35	med. fast	11.5	2720	2.94	516	0	2210	- -
11/3/80 1:25	med. fast	12.5	2900	2.97	496	0		- -
11/10/80 2:05	med. fast	12.0	2970	2.91	488	0		- -
11/19/80 2:40	med. fast	11.5	2880	2.94	489	0		- -
11/24/80 1:20	med. fast	11.5	2270	2.90	467	0		- -
12/1/80 1:25	med. fast	11.0	2870	2.90	486	0	1960	- -
12/8/80 1:10	med. fast	11.5	2820	2.92	470	0		- -
12/22/80 1:58	med. slow	10	2700	3.51	472	0		- -
12/29/80 1:03	med. fast	10	2710	2.96	470	0	2050	- -
1/6/81 4:45	med. slow	9	2100	3.00	365	0		- -
1/19/81 1:13	medium	8.0	3000	2.89	515	0		- -
1/26/81 12:50	medium		2880	2.85	525	0	2000	- -
2/13/81 1:10	medium		2350	2.97	396	0		- -
2/17/81 3:43	med. fast	9.5	2500	2.98	478	0		- -
2/25/81 4:20	fast	9.0	2600	2.98	466	0	1800	- -
3/4/81 3:40	med. fast	9.5	2810	3.02	458	0		- -
3/11/81 12:55	med. fast	9.0	2700	3.0	466	0		- -
3/16/81 2:03	med. fast	9.0	2980	2.97	472	0		- -
3/23/81 2:00	med. fast	9.5	3025	2.95	478	0	2050	- -

Bedway Site, Fairview, Ohio
Sample Location # 5 (cont.)

Date & Time of Collection	Q	Temp. ^{o}C	S. Cond. umho/cm	pH	Acidity mg/l as $CaCO_3$	Alkalinity mg/l as $CaCO_3$	Sulfate mg/l	Tracer $Br^-F^-I^-$
4/3/81 4:28	med. fast	9.5	2880	2.98	526	0		- -
4/19/81 11:30 am	very fast	10.0	2730	2.85	602	0		- -
4/25/81 12:30	med. fast	10.5	2720	2.83	792	0	2175	- -
5/1/81 6:35	fast	10.0	2760	3.08	700	0		- -
5/9/81 7:30	fast		2800	3.05	630	0		- -
5/15/81 11:00	very fast		2800	3.00	571	0		- -
5/24/81 12:28	med. fast	10.0	2900	3.00	554	0		- -
5/31/81 12:00	fast	10.0	2750	3.09	510	0		- -
6/7/81 11:25	fast	11.0	2790	3.08	490	0		- -
6/16/81 10:25	fast	11.0	2450	3.10	485	0		- -
6/26/81 6:24	fast	12.0	2400	3.40	416	0		- -
7/7/81 5:45	med. fast	11.0	2620	3.10	541	0		- -
7/15/81 7:30	medium	17.0	2780	2.83	520	0		- -
7/22/81 7:25	med. fast	12.0	2720	3.08	520	0		- -
7/29/81 9:55	fast	11.5	2920	3.18	437	0		- -
8/4/81 8:33	med. fast	12.0	2600	3.25	458	0		- -
8/12/81 6:30	med. fast	12.0	2690	3.02	363	0		- -
8/20/81 6:30	med. fast	12.0	2900	3.10		0		- -
8/27/81 6:55	medium	14.0	2800	3.0	349	0		- -
9/1/81 6:30	medium	12.0	2420	2.98	413	0		- -
9/9/81 6:30	med. fast	12.5	2300	3.10				

Bedway Site, Fairview, Ohio
Sample Location # 6

Date & Time of Collection	Q	Temp. ^oC	S. Cond. umho/cm	pH	Acidity mg/l as $CaCO_3$	Alkalinity mg/l as $CaCO_3$	Sulfate mg/l	Tracer Br-F-I-
11/17/78 1 pm	0.06 cfs	12	2700	3.15	394	0	2275	- -
4/2/79	0.08 cfs	11.1	2600	2.80	621	0	2835	- -
6/13/79		12	3510	2.70	691	0		
6/16/79 1:10		11	3410	2.62	684	0		
6/22/79 2:00		11	3350	2.90	679	0		
6/29/79 5:45	good	11	3300	2.95	642	0	2300	- -
7/7/79 4:20	good	12	3190	2.85	642	0		
7/16/79 5:40		10.5	3180	3.20	675	0		
7/23/79 4:15	good	11	3390	2.88	563	0		
7/30/79 4:15	good	7.5	3350	2.78	588		2340	- -
8/6/79	medium		3390	2.86	588			
8/13/79 3:30	good	9	3060	2.85	588			
8/22/79 3:30	good	9	2960	2.96	519			
8/28/79 3:23	good	13	3050	2.76	581	0	1880	- -
9/4/79 2:55	good	14	3260	2.58	718	0		
9/10/79 2:50	good	13.5	3080	2.70	658	0		
9/17/79 3:40	good	14	2990	2.82	565	0		
9/24/79 1:50	good	12.5	2880	2.84	612	0	1975	- -
10/1/79 2:08	good	13	2780	2.92	575	0		
10/9/79 11:35	fast	13	2810	2.85	304	0		
10/15/79 1:33	fast	12.5	2800	2.90	525	0		- -
10/23/79 11:28	good	13	2760	2.96	523	0		- -
10/29/79 1:30	good	12.5	2530	3.10	508	0	1950	- T
11/5/79 1:35	fast	12	2800	3.05	540	0		
11/12/79 1:40	good	13	2860	3.18	547	0		- T
11/18/79 3:55	good	13	2900	2.98	523	0		- -
11/26/79 2:10	good	12	2920	3.00	584	0	1975	- T
12/3/79 1:55	good	12	2820	3.20	555	0		- T
12/10/79 2:20	good	11	2800	3.02	563	0		
12/17/79 2:45	good	10.5	2820	2.90	577	0		

Bedway Site, Fairview, Ohio
Sample Location # 6 (cont.)

Date & Time of Collection	Q	Temp. °C	S. Cond. umho/cm	pH	Acidity mg/l as $CaCO_3$	Alkalinity mg/l as $CaCO_3$	Sulfate mg/l	Tracer $Br^-F^-I^-$
12/24/79 12:45	good	11.5	2150	2.90	535	0	2100	- -
1/2/80 1:00	good	11	2250	2.85	566	0		
1/8/80 4:30 pm	good	11	2860	2.95	556	0		
1/14/80 1:05	fast	12.0	3220	2.99	661	0		
1/22/80 5:37 pm	good	10		3.05	669	0		
2/1/80 3:00	good	9.0	3110	3.11	622	0		- -
2/4/80 11:45	good	9.5	3190	3.10	613	0		- -
2/11/80 11:55	good	9.5	3110	2.95	605	0		
2/19/80 4:40 pm	good	11.0	3130	3.10	533	0		
2/25/80 12:34 pm	good	10.0	2990	5.03	493	0		
3/3/80 11:30 am	good	9.0	3020	3.01	559	0		
3/10/80 11:50 am	good	9.5	2950	3.01	529	0		
3/17/80 11:55	good	9.0	3080	3.00	593	0		
3/23/80 2:18 pm	good	9.0	3230	2.78	828	0		
3/31/80 2:12 pm	good	8.5	3520	2.75	888	0	2425	- -
4/7/80 1:45	good	9.0	3340	2.80	746	0		
4/14/80 3:23	fast		2900	2.80	703	0		
4/21/80 12:28	medium	9.5	3480	2.70	958	0		
4/28/80 12:28	good	9.0	3440	2.19	894	0	2425	- -
5/5/80 12:57	fast	9	3340	2.68	938	0		- -
5/12/80 2:00	fast	9	3370	2.74	863	0		- -
5/19/80 2:39	fast	9	3160	2.80	761	0		- -
5/29/80 1:35	fast	11	3120	2.78	706	0	1680	- -
6/3/80 1:04	fast	10	3000	2.72	691	0		- -
6/9/80 12:35	fast	10	3020	2.77	688	0		- -
6/18/80 12:23	fast	11	3100	3.00	602	0		- -
6/24/80 6:55	fast	11	3240	3.05	464	0	1930	- -
7/3/80 4:35	fast	11.5	3120	3.03	533	0		- -
7/9/80 9:58	fast	12	3150	2.79	549	0		- -
7/15/80 2:30	slow	11	3230	2.98	470	0		- -
7/25/80 7:28	medium	12	3030	2.99	442	0		- -

Bedway Site, Fairview, Ohio
Sample Location # 6 (cont.)

Date & Time of Collection		Q	Temp. ^0C	S. Cond. umho/cm	pH	Acidity mg/l as $CaCO_3$	Alkalinity mg/l as $CaCO_3$	Sulfate mg/l	Tracer $Br^-F^-I^-$
8/8/80	10:00	med. slow	13	3050	2.93	480	0	1630	- -
8/14/80	7:57	medium		3010	2.83	495	0		- -
8/22/80	12:00	slow		3000	2.90	489	0		- -
8/28/80	3:05	very slow	14	3060	2.81	491	0		- -
9/7/80	8:33	slow	15		2.86	547	0		- -
9/16/80	3:58	slow		3180	2.91	553	0	1875	- -
9/22/80	2:03	slow	14	3160	2.90	522	0		- -
10/1/80	1:35	med. slow	14	3140	2.92	534	0		- -
10/6/80	1:30	med. slow	12.5	3120	3.03	525	0	2000	- -
10/15/80	12:03				2.98	538	0		- -
10/20/80	1:49	med. slow	13	2800	3.07	483	0		- -
10/27/80	2:40	med. slow	13	2560	3.13	481	0		- -
11/3/80	1:29	med. slow	13.2	2680	3.17	480	0	1875	- -
11/10/80	2:01	med. slow	12.0	2810	3.04	488	0		- T
11/19/80	2:45	med. slow	12.0	2880	3.05	456	0		- -
11/24/80	1:28	med. slow	12	2140	2.92	437	0		- -
12/1/80	1:30	med. slow	11.5	2750	2.99	419	0		- -
12/8/80	1:15	slow	12	2790	3.02	452	0	1850	- -
12/22/80	2:03	slow	10.5	2590	3.00	447	0		- T
12/29/80	1:09	med. slow	10.5	2490	3.16	418	0		
1/6/81	4:50	slow	9	1720	3.34	509	0	1920	- -
1/19/81	1:18	medium	8.5	2790	3.00	412	0		
1/26/81	12:53	slow		2720	3.05	445	0		
2/13/81	1:14	slow		2740	2.90	408	0		- -
2/17/81	3:50	med. slow	3.0	2450	2.89	448	0	1870	- -
2/25/81	4:25	slow	9.0	2500	2.87	618	0		- -
3/4/81	3:44	slow	8.0	2760	2.85	512	0	1650	- -
3/11/81	1:00	medium	8.0	2680	2.85	544	0		- -
3/16/81	2:08	slow	8.0	2960	2.80	590	0		- -
3/23/81	2:03	slow	9.0	3050	2.78	648	0	1875	- -

Bedway Site, Fairview, Ohio
Sample Location # 6 (cont.)

Date & Time of Collection		Q	Temp. °C	S. Cond. umho/cm	pH	Acidity mg/l as $CaCO_3$	Alkalinity mg/l as $CaCO_3$	Sulfate mg/l	Tracer $Br^-F^-I^-$
4/3/81	4:33	med. slow	10.0	2800	2.80	704	0		– –
4/19/81	11:35 am	fast	9.0	2650	2.73	664	0		– –
4/25/81	12:34	slow	9.0	2660	2.69	582	0		– –
5/1/81	6:39	med. slow	8.5	2700	2.93	586	0	1750	– –
5/9/81	7:33	med. slow		2810	2.87	726	0		– –
5/15/81	11:04	medium		2750	2.70	670	0		– –
5/24/81	12:30	med. slow	9.5	3000	2.78	667	0		– –
5/31/81	12:04	medium	9.5	2710	2.82	571	0		– –
6/7/81	11:28	medium	10.0	2780	2.80	635	0		– –
6/16/81	10:30	medium	11.0	2410	2.90	531	0		– –
6/26/81	6:28	med. slow	12.0	2380	3.00	458	0		– –
7/7/81	5:48	very slow	13.0	2500	2.80	520	0		– –
7/15/81		dry							
7/22/81		dry							
7/29/81	10:01	slow	13.0	2680	3.10	458	0		– –
8/4/81	8:37	medium	12.0	2600	2.98	530	0		– –
8/12/81	6:34	slow	12.5	2710	2.90				

Bedway Site, Fairview, Ohio
Sample Location # 7

Date & Time of Collection		Q	Temp. °C	S. Cond. umho/cm	pH	Acidity mg/l as $CaCO_3$	Alkalinity mg/l as $CaCO_3$	Sulfate mg/l	Tracer $Br^-F^-I^-$
6/11/79		0.01 cfs		1510	7.10	23.5	134		- -
6/16/79	11 am	0.04 cfs	19	1780	7.80		160		
6/22/79	5:35 pm			1800	7.05	0	165		
6/29/79	2:00	low	11	1760	7.40	0	154	930	- -
7/7/79	4:17	very low	23	1830	7.40	0	143		
7/14/79	5:15	very low	21	1780	7.40		143		
7/23/79		dry							
7/30/79	1:25	very slow	33	1680	7.8	5.4	170.5	1000	- -
8/6/79		dry							
8/13/79	12:50	very slow	22.5	1580	7.7 (field) 6.4 (lab)	0	160		
8/22/79	1:55	very slow	22	1580	8.9 (lab)	3.8	187		
8/28/79	1:40	slow	16.5	1500	8.3	0	187	710	- -
9/4/79	1:30	very slow	17.5	1680	6.5 (lab)	6.9	204		
9/10/79	1:40	slow	17.5	1680	8.3	7.1	171		
9/17/79	2:53	slow	16	1700	8.1	0	165		
9/24/79	1:04	medium	17	1620	7.8	5.5	171	900	- -
10/1/79	1:05	slow	11	1490	8.5	6.4	165		-
10/9/79	10:40	slow	14	1610	8.5	0	168		
10/15/79	12:12	med. slow	12	1620	8.4	0	170		- -
10/23/79	10:32	fast	13	1660	7.6	3.3	164		- -
10/29/79	12:11	slow	15	1570	7.9	5.7	163	1050	- -
11/5/79	12:09	slow	14	1720	8.0	2	165		
11/12/79	12:00	slow	11.5	1600	8.0	4.4	158		- -
11/18/79	1:35	slow	11	1710	8.0	0	143		- -
11/26/79	11:36	medium	11	1100	7.9	0	82	520	- -
12/3/79	12:28	slow	9.0	1620	8.1	2.5	163		- -
12/10/79	2:25	slow	10	1580	8.0	0	163		
12/17/79	12:46	slow	8	1540	7.9	0	158		
12/24/79	11:18	slow	11	1300	7.7	0	185	770	

Bedway Site, Fairview, Ohio
Sample Location # 7 (cont.)

Date & Time of Collection	Q	Temp. °C	S. Cond. umho/cm	pH	Acidity mg/l as $CaCO_3$	Alkalinity mg/l as $CaCO_3$	Sulfate mg/l	Tracer $Br^-F^-I^-$
1/2/80 10:57	slow	8	1210	8.2	0	215		- -
1/8/80 3:32	slow	7	1450	8.5	0	210		
1/14/80 11:12	medium	9.0	1560	8.0	0	200		
1/22/80 3:42	medium	8.5		8.2	2.40	200		
2/1/80 2:04	slow	7.0	1600	8.0	0	200		
2/4/80 10:33 am	slow	5.0	1620	8.2	0	185		- -
2/11/80 10:36 am	very slow	5.0	1650	8.5	0	180		- -
2/19/80 4:19 pm	slow	6.0	1660	8.4	0	193		
2/25/80 10:48	slow	8.0	1470	8.0	0	155		
3/3/80 10:42	slow	5.5	1650	8.4	0	180		
3/10/80 10:34	good	6.0	1430	8.1	10	148		
3/17/80 10:47	fast	8.0	1390	7.9	1	126		
3/23/80 12:44 pm	fast	8.0	1410	6.60	0	147		
3/31/80 12:47 pm	fast	8.0	1400	6.43	0	95	525	- -
4/7/80 12:22 pm	medium	8.0	1550	6.45	0	113		
4/14/80 4:50	slow		730	6.30	0	50		
4/21/80 1:35	very slow	10	1570	6.70	10	73		
4/28/80 1:25	slow	11.5	1570	8.00	0	167	740	- -
5/5/80 2:08	very slow	16	1590	6.71	0	166		- -
5/12/80	not collected							
5/19/80 3:53	slow	12	1330	7.02	2	146		- -
5/29/80 3:15	very slow	14	1620	6.82	0	80	780	- -
6/3/80 2:05	very slow	12	1270	6.52	0	95		- -
6/9/80 1:45	very slow	12	1580	7.67	3	121		- -
6/18/80 1:10	very slow	16	1710	7.20	1	168		- -
6/24/80 7:40	very slow	14	1870	7.09	0	121	870	- -
7/3/80 5:35	very slow	18	1850	6.82	0	113		- -
7/9/80 11:10	very slow	16	1760	6.98	3	121		- -
7/15/80 3:10	very slow	26	1890	7.04	0	121		- -
7/25/80 7:50	very slow	14	1810	7.99	2	121		- -
8/8/80 11:35 am	very slow	18	1710	7.93	0	115	730	- -

Bedway Site, Fairview, Ohio
Sample Location # 7 (cont.)

Date & Time of Collection	Q	Temp. oC	S. Cond. umho/cm	pH	Acidity mg/l as $CaCO_3$	Alkalinity mg/l as $CaCO_3$	Sulfate mg/l	Tracer $Br^-F^-I^-$
8/14/80 9:25	very slow		1610	7.23	0	115		- -
8/22/80 1:45	very slow		1560	7.21	0	105		- -
8/28/80 4:10	very slow	14	1760	7.12	0	115		- -
9/7/80 9:35	very slow	16		7.61	0	105	920	- -
9/16/80 4:08	very slow		1860	7.14	0	105		- -
9/22/80 1:25	very slow	18	1860	7.52	0	125		- -
10/1/80 1:13	very slow	18	1860	7.32	0	122	975	- -
10/6/80 12:55	very slow	13	1920	7.31	0	105		- -
10/15/80 11:40	very slow	12	1880	7.32	1	121		- -
10/20/80 1:05	very slow	9.5	1680	7.43	0	121		- -
10/27/80 1:40	very slow	9	1510	7.44	0	177	1210	- T
11/3/80	dry							
11/10/80	dry							
11/19/80	dry							
11/24/80 2:10	slow	6.5	820	7.32	0	122		- -
12/1/80 2:00	very slow	10	1420	7.12	0	147	740	- -
12/8/80 2:00	very slow	11	1320	7.49	0	147		- -
12/22/80	frozen							
12/29/80	frozen							
1/6/81	frozen							
1/19/81	frozen							
1/26/81	very slow	2.0	1210	7.45	0	145	625	- -
2/13/81 1:30	very slow	5.0	1110	7.20	0			
2/17/81 4:25	very slow	3.0	1700	7.10	0	85		- T
2/25/81 4:50	very slow	3.0	1050	7.16		131	580	- -
3/4/81 4:20	very slow	5.0	1430	7.10	1	159		- -
3/11/81 1:45	very slow	7.0	1360	6.95	0	176		- T
3/16/81 2:55	very slow	6.5	1500	6.80	1	167		- T
3/23/81 2:50	very slow	7.0	1550	6.90	0	165	740	- -
4/3/81 5:02	very slow	9.0	1450	6.85	0	157		- -

Bedway Site, Fairview, Ohio
Sample Location # 7 (cont.)

Date & Time of Collection		Q	Temp. oC	S. Cond. umho/cm	pH	Acidity mg/l as $CaCO_3$	Alkalinity mg/l as $CaCO_3$	Sulfate mg/l	Tracer $Br^-F^-I^-$	
4/19/81	12:08	slow	8.5	1270	6.65	0	140		-	-
4/25/81	1:08	very slow	9.0	1370	6.70	0	148	770	-	-
5/1/81	7:10	very slow	8	1420	7.01	0	115		-	-
5/9/81	7:20	very slow		1500	6.90	0	154		-	-
5/15/81	11:23 am	very slow		1120	7.00	0	95		-	-
5/24/81	12:55	very slow	16.0	1600	6.82	0	147		-	-
5/31/81	1:20	very slow	16.0	1480	6.85	0	153		-	-
6/7/81	12:55	very slow	15.0	1390	6.80	0	113		-	-
6/16/81	11:05 am	very slow	15.0	1350	7.23	0	113		-	-
6/26/81	7:09	very slow	13.0	1210	7.20	0	117		-	-
7/7/81	7:10	very slow	13.0	1590	7.20	1	121		-	-
7/15/81	8:00	very slow	16.0	1620	6.80	6	121		-	-
7/22/81	7:55	very slow	16.0	1600	7.20	0	150		-	-
7/29/81	10:20	very slow	15.0	1410	7.22	0	120		-	-
8/4/81	9:00	very slow	16.0	1510	7.10	0	150		-	-
8/12/81	7:02	very slow	15.0	1710	7.90					

Bedway Site, Fairview, Ohio
Sample Location # 8

Date & Time of Collection	Q	Temp. °C	S. Cond. umho/cm	pH	Acidity mg/l as $CaCO_3$	Alkalinity mg/l as $CaCO_3$	Sulfate mg/l	Tracer $Br^-F^-I^-$
11/17/79 2 pm	0.4 cfs	9.5	2600	3.1	604	0	2450	-
4/2/79 5 pm					813	0		- - -
6/11/79 5 pm			2630	2.99	869	0		- - -
6/16/79 12 pm	0.2 cfs	18.5	3430	2.80	755	0		
6/22/79 5:30 pm		17	3300	2.88	775	0		
6/29/79 2:00		19	3490	2.90	871	0	2550	- - -
7/7/79 4:15		24	3200	2.88	735	0		
7/14/79 5:13		22	3320	3.12	811	0		
7/23/79 1:45	good	24	3700	2.80	798	0		
7/30/79 1:15	good	24	3220	2.74	680	0	2300	- - -
8/6/79 12:20	fast	24	3500	2.88	755	0		
8/13/79 12:45	good	13	2710	2.85	546	0		
8/22/79 1:35	fast	19	2940	3.00	665	0		
8/28/79 1:35	very good	20	2590	2.86	493	0	1650	- - -
9/4/79 1:25	good	21	3080	2.70	709	0		
9/10/79 1:35	fast	18	3130	2.78	849	0		
9/17/79 2:50	good	20.5	3080	2.75	746	0		
9/24/79 1:00	fast	15	2920	2.84	758	0	1900	- - -
10/1/79 1:02	fast	16	2620	2.98	629	0		
10/9/79 10:36	fast	13	2700	2.88	857	0		-
10/15/79 12:10	med. fast	12	2760	2.88	857	0		- - -
10/23/79 10:30	fast	15	2850	2.90	698	0		- - -
10/29/79 12:09	med. fast	10	2600	3.18	656	0	2330	- - -
11/5/79 12:07	med. fast	7	2910	3.08	857	0		-
11/12/79 11:57	med. fast	5	2590	3.46	398	0		- - -
11/18/79 1:25	good	9	2950	3.02	652	0		- - -
11/26/79 11:36	fast	11	2520	3.18	455	0	1770	- T
12/3/79 12:25	medium	3.0	2810	3.3	584	0		- - -
12/10/79 2:30	med. fast	2.5	2740	3.2	584	0		
12/17/79 12:44	fast	5	2700	3.08	564	0		-
12/24/79 11:15	fast	7	2080	3.00	587	0	2125	- - -

Bedway Site, Fairview, Ohio
Sample Location # 8 (cont.)

Date & Time of Collection		Q	Temp. °C	S. Cond. umho/cm	pH	Acidity mg/l as $CaCO_3$	Alkalinity mg/l as $CaCO_3$	Sulfate mg/l	Tracer $Br^-F^-I^-$
1/2/80	10:55	med. fast	2.5	2100	3.04	566	0		
1/8/80	3:30	medium	2	2490	3.18	536	0		
1/14/80	11:09	fast	3.5	2600	3.02	462	0		
1/22/80	3:40	med. fast	3.5		3.35	530	0		-
2/1/80	2:00	medium	1.5	2420	2.59	603	0		- - -
2/4/80	10:30	medium	0	3130	3.29	683	0		- -
2/11/80	10:32	medium	0	3080	3.09	637	0		
2/19/80	4:22 pm	fast	0	3080	3.22	578	0		
2/25/80	10:45	med. fast	1.5	2580	3.28	399	0	1625	- - -
3/3/80	10:39	medium	0.5	3150	3.10	616	0		
3/10/80	10:30	good	1.0	2380	3.20	372	0		
3/17/80	10:45	fast	8.0	2300	3.29	318	0		
3/23/80	12:42 pm	fast	7.0	1570	4.38	122	0		
3/31/80	12:45	fast	9.0	2600	3.10	435	0	1325	- - -
4/7/80	12:20	good	9.0	2880	3.00	234	0		
4/14/80	4:55	fast		1650	3.27	287	0		
4/21/80	1:38	good	17	2920	3.15	622	0		
4/28/80	1:28	good	11.5	2890	3.04	630	0	2075	- -
5/5/80	2:12	fast	19	2910	2.98	663	0		
5/12/80		not collected							- -
5/19/80	3:58	fast	17	2440	3.13	455	0		- -
5/29/80	3:20	fast	22	2970	2.96	653	0	2040	- -
6/3/80	2:10	fast	19	2120	3.06	377	0		- -
6/9/80	1:49	fast	15	2700	3.01	582	0		- -
6/18/80	1:15	fast	18	3030	3.11	660	0		- -
6/24/80	7:43	fast	20	3310	3.09	598	0	2040	- -
7/3/80	5:40	fast	25	3390	3.04	708	0		- -
7/9/80	11:15	fast	19	2980	2.87	560	0		- -
7/15/80	3:20	fast	27	3380	3.07	620	0		- -
7/25/80	7:45	fast	21	2010	3.10	442	0		- -
8/8/80	11:30	fast	18	2900	3.11	442	0	1820	- -

Bedway Site, Fairview, Ohio
Sample Location # 8 (cont.)

Date & Time of Collection	Q	Temp. ^oC	S. Cond. umho/cm	pH	Acidity mg/l as $CaCO_3$	Alkalinity mg/l as $CaCO_3$	Sulfate mg/l	Tracer $Br^-F^-I^-$
8/14/80 9:28	fast		3000	2.95	609	0		- -
8/22/80 1:50	fast		2630	3.09	487	0		- -
8/28/80 4:15	fast	21	3120	2.93	619	0		- - -
9/7/80 9:42	fast	18		3.04	626	0	2050	- - -
9/16/80 4:12	fast		3200	3.08	685	0		- - -
9/22/80 1:20	fast	21	3180	3.02	716	0		- - -
10/1/80 1:05	fast	16	3220	3.08	622	0	1980	- - -
10/6/80 12:45	fast	9	3220	3.08	648	0		- - -
10/15/80 11:30	fast	9	3240	3.08	622	0		- - -
10/20/80 1:00	very fast	9	2840	3.11	536	0		- - -
10/27/80 1:30	fast	7	2500	3.21	518	0	2040	- - -
11/3/80 12:45	fast	7	2730	3.20	559	0		T - T
11/10/80 1:10	fast	9	2830	3.13	602	0		- - -
11/19/80 3:15	fast	3.5	2710	3.18	510	0		- - -
11/24/80 2:15	very fast	5.5	1630	3.19	381	0		- - -
12/1/80 2:05	very fast	5.5	2510	3.20	437	0	1890	- - -
12/8/80 2:10	very fast	8	2580	3.18	490	0		- - T
12/22/80 2:00	fast	0.5	2680	3.17	538	0		- - -
12/29/80 1:20	very fast	0.5	2460	3.22	492	0	2060	- - -
1/6/81 4:15	med. fast	0	2320	3.27	494	0		- - -
1/19/81 1:15	fast	0.5	2720	3.12	555	0		- - -
1/26/81 1:45	very fast	1.5	2450	3.25	415	0	1780	- - -
2/13/81 1:35	fast	0	1800	3.23	348	0		- - -
2/17/81 4:32	very fast	0	1450	3.42	192	0		- -
2/25/81 4:45	very fast	3.0	1850	3.28	292	0	1270	- -
3/4/81 4:15	very fast		2450	3.13	440	0		- - -
3/11/81 1:40	fast	4.0	2440	3.18	460	0		- - -
3/16/81 2:50	fast	6.0	2500	3.20	434	0		- - -
3/23/81 2:45	very fast	11.0	2640	3.15	464	0	1800	- - -
4/3/81 4:55	fast	15.0	2650	3.14	522	0		- - -

Bedway Site, Fairview, Ohio
Sample Location # 8 (cont.)

Date & Time of Collection		Q	Temp. °C	S. Cond. umho/cm	pH	Acidity mg/l as $CaCO_3$	Alkalinity mg/l as $CaCO_3$	Sulfate mg/l	Tracer $Br^-F^-I^-$
4/19/81	12:01	very fast	10	2220	3.05	466	0		- -
4/25/81	1:05	very fast	7.0	2400	2.94	620	0	1680	- -
5/1/81	7:08	very fast	14.0	2520	3.26	570	0		- -
5/9/81	7:24	very fast	7.0	2560	3.22	534	0		- -
5/15/81	11:20	very fast		2100	3.38	385	0		
5/24/81	12:50	fast	16.0	2700	3.08	544	0		- -
5/31/81	12:35	fast	19.0	2400	3.20	459	0		- -
6/7/81	12:58	very fast	15.0	2280	3.28	375	0		- -
6/16/81	11:00	very fast	15.0	2200	3.17	298	0		- -
6/26/81	7:03	very fast	18.0	2050	3.47	354	0		- -
7/7/81	7:19	fast	23.0	2640	3.08	641	0		- -
7/15/81	7:55	fast	21.0	2800	3.00	416	0		- -
7/22/81	8:00	very fast	22.0	2700	3.15	572	0		- -
7/29/81	10:25	very fast	16.5	2000	3.48	344	0		- -
8/4/81	9:05	very fast	17.0	2220	3.37	374	0		- -
8/12/81	6:55	fast	17.0	2700	3.02				

Bedway Site, Fairview, Ohio
Sample Location # 9

Date & Time of Collection	Q	Temp. oC	S. Cond. umho/cm	pH	Acidity mg/l as $CaCO_3$	Alkalinity mg/l as $CaCO_3$	Sulfate mg/l	Tracer $Br^-F^-I^-$
4/2/79	very low	8.9	520	7.15	2	166	270	
6/11/79	dry							
6/16/79	dry							
6/22/79	dry							
6/29/79	dry							
7/7/79	dry							
7/14/79	dry							
7/23/79	dry							
7/30/79	dry							
8/6/79	dry							
8/13/79	dry							
8/22/79	dry							
8/28/79	dry							
9/4/79	dry							
9/10/79	dry							
9/17/79	dry							
9/24/79	dry							
10/1/79	dry							
10/9/79	dry							
10/10/79-3/23/80	dry							
3/31/80 1:10	slow	8.0	1060	6.50	4		370	
4/7/80	no flow							
4/14/80 5:15	slow		435	5.90	0	43		
4/21/80	no flow							
4/28/80	no flow							
5/5/80	dry							
5/12/80	not collected							
5/19/80	no flow							
5/29/80	dry							
6/3/80	dry							
6/9/80	dry							
6/18/80	dry							

Bedway Site, Fairview, Ohio
Sample Location # 9 (cont.)

Date & Time of Collection	Q	Temp. °C	S. Cond. umho/cm	pH	Acidity mg/l as $CaCO_3$	Alkalinity mg/l as $CaCO_3$	Sulfate mg/l	Tracer $Br^-F^-I^-$
6/24/80	dry							
7/3/80	dry							
7/9/80	dry							
7/15/80	dry							
7/25/80	dry							
8/8/80	dry							
8/14/80	dry							
8/22/80	dry							
8/28/80	dry							
9/7/80	dry							
9/16/80	dry							
9/22/80	dry							
10/1/80	dry							
10/6/80	dry							
10/15/80	dry							
10/20/80	dry							
10/27/80	dry							
11/3/80	dry							
11/10/80	dry							
11/19/80	dry							
11/24/80	dry							
12/1/80	dry							
12/8/80	dry							
12/22/80	dry							
12/29/80	dry							
1/6/81	frozen							
1/19/81	frozen							
1/26/81	dry							
2/13/81	frozen							
2/17/81	dry							
2/25/81	dry							

Bedway Site, Fairview, Ohio
Sample Location # 9 (cont.)

Date & Time of Collection	Q	Temp. °C	S. Cond. umho/cm	pH	Acidity mg/l as $CaCO_3$	Alkalinity mg/l as $CaCO_3$	Sulfate mg/l	Tracer $Br^-F^-I^-$
3/4/81	dry							
3/11/81	dry							
3/16/81	dry							
3/23/81	dry							
4/3/81	dry							
4/19/81	dry							
4/25/81	dry							
5/1/81	dry							
5/9/81	dry							
5/15/81	dry							
5/24/81	dry							
5/31/81	dry							
6/6/81	dry							
6/16/81	dry							
6/26/81	dry							
7/7/81	dry							
7/15/81								
7/22/81								
7/29/81								
8/4/81								
8/12/81								

Bedway Site, Fairview, Ohio
Sample Location # 10

Date & Time of Collection	Q	Temp. ^{o}C	S. Cond. umho/cm	pH	Acidity mg/l as CaCO$_3$	Alkalinity mg/l as CaCO$_3$	Sulfate mg/l	Tracer Br-F-I-
4/2/79	0.08 cfs	8.9	4690	3.0		0		- - -
6/11/79 2 pm	0.02 cfs	17.4	5000	2.82	2250	0		- - -
6/16/79 11:05 pm	18 in^3/sec	17.8	5710	2.80	1720	0		
6/22/79 4:45 pm		19	5750	2.90	1940	0		
6/29/79 2:35 pm	little	19	5800	2.90	1860	0	5050	- - -
7/7/79 4:47 pm	little	20	5680	2.85	1665	0		
7/14/79 5:40	little	22	5600	3.10	1880	0		- - -
7/23/79 2:20	very little	19.5	6050	2.78	2035	0		- - -
7/30/79 2:30	very slow	22	5510	2.82	1780	0	4725	- T -
8/6/79 1:30	very slow	22	5750	2.85	1560	0		
8/13/79 2:00	slow	14	4600	2.68	1300	0		
8/22/79 2:20	slow	18	4800	2.95	1480	0		
8/28/79 2:25	slow	21	4210	2.90	1090	0	3250	- T -
9/4/79 2:05	slow	22.5	4870	2.76	1430	0		
9/10/79 2:08	slow	20	5010	2.85	1700	0		- T -
9/17/79 3:25	medium	20	5040	2.90	1570	0		
9/24/79 1:45	medium	16	4820	2.94	1510	0	4355	
10/1/79 1:45	medium	18	4540	3.05	1360	0		- T -
10/9/79 11:15	medium	14	4600	3.00	1300	0		- T -
10/15/79 12:45	medium	11.5	4800	3.08	1400	0		- T -
10/23/79 11:15	medium	13	4930	3.04	1500	0		- T -
10/29/79 12:45	slow	14	4620	3.18	1420	0	4550	- T -
11/5/79 12:44	slow	11.5	5220	3.16	1150	0		T
11/12/79 12:24	slow	0	5010	3.40	1580	0		- T -
11/18/79 2:35	slow	12	5270	3.06	1450	0		- - -
11/26/79 12:22	medium	11	4200	3.22	1220	0	3510	- T
12/3/79 1:15	slow	5	4800	3.30	1480	0		- -
12/10/79 1:43	medium	6	4800	3.18	1420	0		
12/17/79 1:04	slow	3.0	4690	3.08	1340	0		
12/24/79 11:56	medium	10	3550	2.95	1102	0		

Bedway Site, Fairview, Ohio
Sample Location # 10 (cont.)

Date & Time of Collection		Q	Temp. ^{o}C	S. Cond. umho/cm	pH	Acidity mg/l as $CaCO_3$	Alkalinity mg/l as $CaCO_3$	Sulfate mg/l	Tracer $Br^-F^-I^-$
1/2/80	11:37	medium	3	3550	3.05	1236	0		
1/8/80	4:00 pm	slow	2	4020	3.15	1185	0		
1/14/80	11:57	medium	4.5	4390	3.01	1170	0		
1/22/80	4:20	medium	5.0		3.39	1195	0	4030	- - -
2/1/80	2:15	frozen							
2/4/80	10:45	frozen							
2/11/80	11:00	frozen							
2/19/80	3:30	frozen							
2/25/80	11:15	medium	3.0	4720	3.22	1190	0	3900	- - -
3/3/80		frozen							
3/10/80	11:05	good	5.0	4550	3.20	1245	0		-
3/17/80	11:42	fast	6.0	3250	3.30	665			
3/23/80	1:13	fast	7.0	4080	3.21	1055			
3/31/80	1:19 pm	fast	10.0	4550	3.18	1155	0	3615	- - -
4/7/80	12:55 pm	medium	9	5000	3.12		0		
4/14/80	5:23	fast			3.28	3170	0		- - -
4/21/80	1:55	medium slow	14.5	5350	3.18	2350	0		
4/28/80	1:40	medium slow	11	5430	3.07	1805	0	4950	
5/5/80	2:25	slow	18	5460	2.94	1765	0		- - -
5/12/80		not collected							
5/19/80	4:15	medium	16	4690	3.08	1374	0		- - -
5/29/80	3:35	slow	17.5	5210	2.93	1571	0	4550	- - -
6/3/80	2:25	slow	19	4150	2.96	1263	0		- - -
6/9/80	1:59	slow	15.0	4740	2.99	1471	0		- - -
6/18/80	1:25	very slow	17	5270	3.11	1495	0		- - -
6/24/80	7:59	very slow	18	5550	3.09	1293	0	4220	- - -
7/3/80	6:05	very slow	24	5590	3.01	1433	0		- - -
7/9/80	11:30	very slow	19	5330	2.79	1484	0		- - -
7/15/80	3:35	very slow	22	lost sample					
7/25/80	9:00	very slow	20	4700	3.04	985	0		- - -
8/8/80	11:48	medium	21	4940	3.11	1071	0	3520	- - -
8/14/80	no sample collected								
8/22/80	1:20	medium slow		5440	3.10	1580	0		- -
8/28/80	4:30	slow	21	5620	3.00	1488	0		- T -
9/7/80	9:55	slow	18		2.88	1712	0	4250	- T -

Bedway Site, Fairview, Ohio
Sample Location # 10 (cont.)

Date & Time of Collection	Q	Temp. ^{o}C	S. Cond. umho/cm	pH	Acidity mg/l as $CaCO_3$	Alkalinity mg/l as $CaCO_3$	Sulfate mg/l	Tracer $Br^-F^-I^-$
9/16/80 4:50	slow		5460	2.93	1550	0		- T -
9/22/80 1:55	slow	21	5460	2.87	1628	0		- T -
10/1/80 1:45	slow	18	5280	2.98	1432	0		- T -
10/6/80 1:25	slow .	11	5340	3.03	1399	0	4510	- T -
10/15/80 12:00	slow	12.5	5340	2.99	1368	0		- T -
10/20/80 1:28	slow	10.5	4800	3.08	1264	0		- T -
10/27/80 2:55	slow	10	4390	3.11	1329	0		- T -
11/3/80 1:15	slow	11	4570	3.11	1401	0	4080	- T -
11/10/80 12:25	very slow	8.5	4700	3.08	1345	0		- T -
11/19/80 2:20	slow	6	4500	3.07	1256	0		- T -
11/24/80 1:25	slow	7	3100	2.98	1186	0		- T -
12/1/80 1:20	slow	8	4500	3.09	1125	0		- T -
12/8/80 1:20	slow	11	4300	3.07	1185	0	3780	- T -
12/22/80	frozen							
12/29/80	frozen							
1/6/81	frozen							
1/19/80	frozen							
1/26/81 12:30	very slow	3.5	2750	3.10	748	0	2350	T
2/13/81	frozen							
2/17/81 3:55	medium	1.0	2930	3.25	685	0		T
2/25/81 4:20	slow		3200	3.34	830	0		T
3/4/81 12:20	slow	5.5	4250	3.27	1510	0	2600	T
3/11/81 12:30	slow	5.0	4250	3.30	1315	0		T
3/16/81 1:45	slow		4620	3.25	1320	0		T
3/23/81 2:00	very slow	9.0	4800	3.20	1300	0		T
4/3/81 4:35	slow	11.0	4550	3.15	1340	0	4500	T
4/19/81 11:30 am	med. fast	9.0	4500	3.13	1715	0		T
4/25/81 11:21 am	med. fast	8.0	4820	3.04	2045	0		T
5/1/81 6:25	slow	5.0	4750	3.32	1555	0	4500	T
5/9/81 7:10	medium	3.0	4830	3.25	1535	0		T

Bedway Site, Fairview, Ohio
Sample Location # 10 (cont.)

Date & Time of Collection		Q	Temp. °C	S. Cond. umho/cm	pH	Acidity mg/l as $CaCO_3$	Alkalinity mg/l as $CaCO_3$	Sulfate mg/l	Tracer $Br^-F^-I^-$
5/15/81	12:15	slow		4220	3.25	1456	0		T
5/24/81	12:08	slow		4800	3.17	1411	0		T
5/31/81	12:35	very slow	15	4370	3.20	1250	0		T
6/7/81	12:06	med. slow	15.5	3840	3.29	974	0		T
6/16/81	11:45 am	slow	17.5	3720	3.28	1719	0		T
6/26/81	6:25	medium	12.0	3450	3.50	962	0		T
7/7/81	6:25	very slow	20.0	4620	3.13	1508	0		T
7/15/81	7:43	slow	19.5	4700	3.11	1357	0		T
7/22/81	7:15	very slow	18.0	4710	3.18	1404	0		T
7/29/81	9:50	med. slow	18.0	3600	3.32	910	0		T
8/4/81	8:15	slow	18.5	4010	3.20	1144	0		- T -
8/12/81	6:15	slow	17.0	4600	3.00				

Bedway Site, Fairview, Ohio
Sample Location # 11

Date & Time of Collection	Q	Temp. ^oC	S. Cond. umho/cm	pH	Acidity mg/l as $CaCO_3$	Alkalinity mg/l as $CaCO_3$	Sulfate mg/l	Tracer Br^--F^--I^-
4/3/79	$12in^3/sec$	9.5	4750	2.70	3045	0	6500	- - -
6/11/79 2 pm	$0.75in^3/sec$		5500	2.65	3220	0		- - -
6/16/79 11:05 am	very low	17.0	6250	2.65	2310	0		- - -
6/22/79 4:45		17.0	6290	2.71	5840	0		
6/29/79 2:35 pm	little	18	6320	2.72	2720	0	5800	- - -
7/7/79 4:40	barely	17	6820	2.70	2580	0		
7/14/79 5:41	trickling	22	6050	2.95	2450	0		
7/23/79	dry							
7/30/79 2:45	very slow	19.5	6210	2.68	2730	0	5450	- - -
8/6/79	dry							
8/13/79 1:50	very slow	18	5540	2.59	2190	0		
8/22/79 2:25	very slow	17	5800	2.75	2090	0		
8/28/79 2:20	very slow	20	5220	2.72	1850	0	4550	- - -
9/4/79 2:10	very slow	20.5	5480	2.62	2150	0		
9/10/79 2:07	dry							
9/17/79 3:30	dry							
9/24/79 1:45	dry							
10/1/79 1:50	very slow	15	5180	2.85	2280	0		- - -
10/9/79 11:15	dry							
10/15/79 12:45	dry							
10/23/79 11:15	dry							
10/29/79 12:45	dry							
11/5/79 12:44	dry							
11/12/79	dry							
11/18/79	dry							
11/26/79 12:29	slow	12	5420	2.98	2150		4850	- - -
12/3/79	dry							
12/10/79	dry							
12/17/79	dry							
12/24/79	dry							
1/2/80	dry							

Bedway Site, Fairview, Ohio
Sample Location # 11 (cont.)

Date & Time of Collection	Q	Temp. oC	S. Cond. umho/cm	pH	Acidity mg/l as $CaCO_3$	Alkalinity mg/l as $CaCO_3$	Sulfate mg/l	Tracer $Br^-F^-I^-$
1/8/80	dry							
1/14/80 12:00	very slow	6.0	4980	3.01	1870			
1/22/80 4:25	very slow	6.0		3.19	1900		4500	- - -
2/1/80	frozen							
2/4/80	dry							
2/11/80	dry							
2/19/80 3:38	slow	3.0	4810	3.11	865			
2/25/80	dry							
3/3/80	frozen							
3/10/80 11:08	dry							
3/17/80 11:35	slow	7.0	5060	3.08	1710			
3/23/80 1:10	fast	7.0	4580	2.99	1640			
3/31/80 1:14 pm	med. fast	8.0	4980	3.00	1755	0	4100	- - -
4/7/80 12:53 pm	medium	9.0	4950	3.00	2090	0		
4/14/80 5:20	very slow		3600	2.99	1545	0		
4/21/80	no flow							
4/28/80	no flow							
5/5/80	dry							
5/12/80	not collected							
5/19/80 4:18 pm	very slow	14.0	5000	2.89	1924	0		- -
5/29/80	dry							
6/3/80 2:30 pm	very slow	16.0	4690	2.77	1808	0		- -
6/9/80	no flow							
6/18/80	dry							
6/24/80	dry							
7/3/80	dry							
7/9/80	dry							
7/15/80	dry							
8/8/80	dry							
8/14/80	no sample collected							
8/22/80	dry							

Bedway Site, Fairview, Ohio
Sample Location # 11 (cont.)

Date & Time of Collection	Q	Temp. ^{o}C	S. Cond. umho/cm	pH	Acidity mg/l as $CaCO_3$	Alkalinity mg/l as $CaCO_3$	Sulfate mg/l	Tracer $Br^-F^-I^-$
8/28/80	dry							
9/7/80	dry							
9/16/80	dry							
9/22/80	dry							
10/1/80	dry							
10/6/80 1:30	very slow	14	5500	2.98	1636	0		- T -
10/15/80 12:05	very slow	13.5	5440	2.98	1405	0		- T -
10/20/80 1:32	very slow	10	5030	3.01	1358	0		- T -
10/27/80 3:00	very slow	10.5	4560	3.03	1523	0	4710	- T -
11/3/80 1:20	very slow	15	4790	3.08	0372	0		- T T
11/10/80 12:35	very slow	9	4930	3.03	1360	0		- T -
11/19/80 12:15	very slow	7	4640	3.06	1344	0		- T -
11/24/80 1:30	slow	8	3230	2.97	1260	0		- T -
12/1/80 1:25	very slow	8.5	4750	3.01	1242	0	4100	- T -
12/8/80 1:25	very slow	11	4590	3.03	1285	0		- T T
12/22/80	frozen							
12/29/80 12:55	very slow	6	4200	3.13	1210	0	4380	- T -
1/6/81	frozen							
1/19/81 1:00	very slow		4700	3.05	1490	0		- T -
1/26/81 12:34	very slow		4510	3.05	1290	0	3960	- T -
2/13/81 1:05	very slow		3900	3.03	1245	0		- T -
2/17/81 4:00	slow	1.5	3670	3.10	1145	0		- T -
2/25/81 4:25	slow		3500	3.11	1340	0		- T -
3/4/81 12:25	slow	7.0	3980	3.10	1580	0	3020	- T -
3/11/81 12:35	slow	6.5	4100	3.10	1190	0		- T -
3/16/81 1:50	very slow		4300	3.06	1280	0		- T -
3/23/81 2:05	very slow	10	4420	3.14	1455	0	3730	- T -
4/3/81	dry							
4/19/81 11:34 am	slow	10	3890	3.00	1570	0		- T -
4/25/81 11:28 am	very slow	9.5	4070	2.85	1550	0	3680	- T -

Bedway Site, Fairview, Ohio
Sample Location # 11 (cont.)

Date & Time of Collection	Q	Temp. ^{o}C	S. Cond. umho/cm	pH	Acidity mg/l as $CaCO_3$	Alkalinity mg/l as $CaCO_3$	Sulfate mg/l	Tracer $Br^-F^-I^-$
5/1/81 6:28	very slow	6.0	4270	3.21	1525	0		- T -
5/9/81 7:13	medium	4	4330	3.10	745	0		- T -
5/15/81 12:18	no flow							
5/24/81 12:12	very slow		4600	3.00	1565	0		- T -
5/31/81	dry							
6/7/81 12:12	very slow	16.0	4030	3.10	1225	0		- T -
6/16/81 11:48	very slow	17.0	3700	3.10	1380	0		- T -
6/26/81 6:28	medium	12.5	3620	3.38	1238	0		- T -

Bedway Site, Fairview, Ohio
Sample Location # 12

Date & Time of Collection	Q	Temp. °C	S. Cond. umho/cm	pH	Acidity mg/l as $CaCO_3$	Alkalinity mg/l as $CaCO_3$	Sulfate mg/l	Tracer $Br^-F^-I^-$
6/16/79 11 am	7½ cfs	16	4480	2.60	1370	0		- - -
6/22/79 12:15		16.5	4410	2.71	1470	0		
6/29/79 2:45	little	17	4510	2.71	1450	0	3525	-
7/7/79	dry							
7/14/79	dry							
7/23/79	dry							
7/30/79	very slow	19.5	4350	2.66	1470		3225	- - -
8/6/79	dry							
8/13/79	very slow	16	4110	2.48	1530			
8/22/79	dry							
8/28/79 2:15	very slow	20	3530	2.88	773		2740	-
9/4/79 2:00	very slow	21.5	4140	2.58	1340			
9/10/79 2:10	dry							
9/17/79 3:30	dry							
9/24/79 1:45	dry							
10/1/79 2:05	very slow	19	3720	2.88	1250			- - -
10/9/79 11:25	very slow	16	3710	2.75	1150			- - -
10/15/79 12:45	dry							
10/23/79 11:15	dry							
10/29/79 12:45	dry							
11/5/79 12:44	dry							
12/12/79	dry							
11/18/79	dry							
11/26/79	dry							
12/3/79	dry							
12/10/79	dry							
12/17/79	dry							
12/24/79	dry							
1/2/80	dry							
1/8/80	dry							

Bedway Site, Fairview, Ohio
Sample Location # 12 (cont.)

Date & Time of Collection	Q	Temp. ^{o}C	S. Cond. umho/cm	pH	Acidity mg/l as $CaCO_3$	Alkalinity mg/l as $CaCO_3$	Sulfate mg/l	Tracer $Br^-F^-I^-$
1/14/80	dry							
1/22/80	dry-recent flow							
2/1/80	dry							
2/4/80	dry							
2/11/80	dry							
2/19/80	unfrozen, no flow							
2/25/80	no flow							
3/3/80	frozen							
3/10/80	no flow							
3/17/80	moist, but no flow							
3/23/80	no flow							
3/31/80 1:25 pm	medium fast	8.0	3750	2.91	1190	0	2670	- - -
4/7/80	dry							
4/14/80 5:27	slow		2900	2.88	545	0		- - -
4/21/80 1:59	very slow	11.0	2900	2.89	1690	0		- - -
4/28/80	no flow							
5/5/80	dry							
5/12/80	not collected							
5/19/80	no flow							
5/29/80	dry							
6/3/80 2:35 pm	very slow	16.0	3200	2.75	926	0		- - -
6/9/80	dry							
6/18/80	dry							
6/24/80	dry							
7/3/80	dry							
7/9/80	dry							
7/15/80	dry							
7/25/80	dry							
8/8/80	dry							
8/14/80	no sample collected							
8/22/80	dry							
8/28/80	dry							

Bedway Site, Fairview, Ohio
Sample Location # 12 (cont.)

Date & Time of Collection	Q	Temp. °C	S. Cond. umho/cm	pH	Acidity mg/l as $CaCO_3$	Alkalinity mg/l as $CaCO_3$	Sulfate mg/l	Tracer $Br^-F^-I^-$
9/7/80	dry							
9/16/80	dry							
9/22/80	dry							
10/1/80	dry							
10/6/80	dry							
10/15/80	dry							
10/20/80	dry							
10/27/80	dry							
11/3/80	dry							
11/10/80	dry							
11/19/80	dry							
11/24/80	dry							
12/1/80	dry							
12/8/80	dry							
12/22/80	dry							
12/29/80	dry							
1/6/81	frozen							
1/19/81	frozen							
1/26/81	dry							
2/13/81	dry							
2/17/81	dry							
2/25/81	dry							
3/4/81	dry							
3/11/81	dry							
3/16/81	dry							
3/23/81	dry							
4/3/81	dry							
4/19/81	dry							
4/25/81	dry							
5/1/81	dry							

Bedway Site, Fairview, Ohio
Sample Location # 12 (cont.)

Date & Time of Collection	Q	Temp. ^oC	S. Cond. umho/cm	pH	Acidity mg/l as $CaCO_3$	Alkalinity mg/l as $CaCO_3$	Sulfate mg/l	Tracer $Br^-F^-I^-$
5/9/81	dry							
5/15/81	no flow							
5/24/81	dry							
5/31/81	dry							
6/7/81	dry							
6/16/81	dry							
6/26/81	dry							

Bedway Site, Fairview, Ohio
Sample Location # 13

Date & Time of Collection		Q	Temp. °C	S. Cond. umho/cm	pH	Acidity mg/l as $CaCO_3$	Alkalinity mg/l as $CaCO_3$	Sulfate mg/l	Tracer $Br^-F^-I^-$
6/11/79	2:45 pm	slow		3120	2.85	1010	0		- - -
6/16/79	10:45 am	7½ cfs	12	3410	2.90	610	0		
6/22/79	4:45 pm		14	3450	2.95	600	0		
6/29/79	2:50	little	14.5	3500	2.95	580	0	2410	- - -
7/7/79		dry							
7/14/79		dry							
7/23/79		dry							
7/30/79	2:15	very slow	17.5	3560	2.90	580	0	2310	- - -
8/6/79	1:25	very slow	18.5	3620	2.90	557	0		
8/13/79	1:35	very slow	11.5	3370	2.70	553	0		
8/22/79	2:05	very slow	14	3360	3.00	503	0		- - -
8/28/79	2:00	very slow	20	3330	2.88	480	0		
9/4/79	1:55	very slow	19.5	3180	2.85	465	0		
9/10/79	2:03	very slow	19.5	3060	2.85	462	0		
9/17/79		dry (oozing)							
9/24/79	1:52	very slow	18	3080	2.90	494	0		- - -
10/1/79	2:07	very slow	21	3020	3.05	471	0	2185	- - -
10/9/79	11:35	medium	15	3010	2.98	432	0		- - -
10/15/79	12:54	slow	19	3020	3.00	471	0		- - -
10/23/79	11:25	slow	15	3020	3.02	463	0		- - -
10/29/79	1:00	slow	17	2800	3.18	488	0	2240	- - -
11/5/79	12:51	slow	15.5	3200	3.12	505	0		
11/12/79	12:34	slow	16	3220	3.28	500	0		- -
11/18/79	2:25	slow	11	3300	3.0	494	0		- - T
11/26/79	12:41	slow	14	3280	3.12	466	0	2360	- -
12/3/79	1:25	slow	13	3170	3.26	457	0		- - -
12/10/79	1:38	slow	12	3100	3.10	476	0		
12/17/79	1:10	slow	7	3080	3.00	484	0		-
12/24/79	12:05	slow	13	2350	2.95	391	0	2250	
1/2/80	11:42	slow	9	2390	3.01	381	0		-
1/8/80	4:10 pm	slow	8	2650	3.05	422	0		

Bedway Site, Fairview, Ohio
Sample Location # 13 (cont.)

Date & Time of Collection		Q	Temp. ^0C	S. Cond. umho/cm	pH	Acidity mg/l as $CaCO_3$	Alkalinity mg/l as $CaCO_3$	Sulfate mg/l	Tracer Br^-	F^-	I^-
1/14/80	12:07	medium	10.0	3210	3.10	327	0				
1/22/80	4:30	slow	8.0		3.28	357	0			-	
2/1/80	2:30	very slow	7.0	3090	3.30	354	0		-		-
2/4/80	11:05	slow	5.0	3150	3.28	401	0		-		-
2/11/80	11:00	very slow	4.0	3180	3.07	363	0				
2/19/80	3:30	stagnant									
2/25/80	11:25	very slow	8.0	3130	3.15	310	0		-	-	-
3/3/80	11:13	very slow	5.5	3220	3.12	380	0				
3/10/80	11:22	slow	8.0	3300	3.11	385	0				
3/17/80	11:55	medium	9.0	3200	3.15	326	0				
3/23/80	1:20	medium	12.0	3020	3.10	342	0				
3/31/80	1:34 pm	medium	12.0	3020	3.11	322	0	1825	-		-
4/7/80	1:11	med. fast	11.0	2910	3.12	325	0				
4/14/80	5:32	very slow		2020	3.10	275	0		-		-
4/21/80		no flow									
4/28/80		no flow									
5/5/80		dry									
5/12/80		not collected									
5/19/80	4:25	very slow	19.0	3050	3.03	407	0		-		-
5/29/80		dry									
6/3/80	2:40	very slow	21	2890	3.02	416	0		-		-
6/9/80	2:08	very slow	15	3010	3.07	422	0		-		-
6/18/80		dry									
6/24/80		dry									
7/3/80		dry									
7/9/80		dry									
7/15/80		dry									
7/25/80		dry									
8/8/80		dry									
8/14/80		no sample collected									
8/22/80		dry									

Bedway Site, Fairview, Ohio
Sample Location # 13 (cont.)

Date & Time of Collection	Q	Temp. °C	S. Cond. umho/cm	pH	Acidity mg/l as $CaCO_3$	Alkalinity mg/l as $CaCO_3$	Sulfate mg/l	Tracer $Br^-F^-I^-$
8/28/80	dry							
9/7/80	dry							
9/16/80	dry							
9/22/80	dry							
10/1/80	dry							
10/6/80	dry							
10/15/80	dry							
10/20/80	dry							
10/27/80	dry							
11/3/80	dry							
11/10/80	dry							
11/19/80	dry							
11/24/80	dry							
12/1/80	dry							
12/8/80	dry							
12/22/80	dry							
12/29/80	dry							
1/6/81	frozen							
1/19/81	frozen							
1/26/81	dry							
2/13/81	dry							
2/17/81	dry							
2/25/81	dry							
3/4/81	dry							
3/11/81	dry							
3/16/81	dry							
3/23/81	dry							
4/3/81	dry							
4/19/81	dry							
4/25/81	dry							

Bedway Site, Fairview, Ohio
Sample Location # 13 (cont.)

Date & Time of Collection	Q	Temp. oC	S. Cond. umho/cm	pH	Acidity mg/l as $CaCO_3$	Alkalinity mg/l as $CaCO_3$	Sulfate mg/l	Tracer $Br^-F^-I^-$
5/1/81	dry							
5/9/81 7:05	very slow	9.0	2700	3.29	285	0		- - -
5/15/81 12:30	very slow		2220	3.20	291	0		- - -
5/24/81	dry							
5/31/81	dry							
6/7/81 12:00	very slow	18.0	2800	3.20	318	0		- T T
6/16/81 12:00	very slow	14.0	2450	3.22	287	0		- - -
6/26/81	dry							

Bedway Site, Fairview, Ohio
Sample Location # 14

Date & Time of Collection		Q	Temp. ^{o}C	S. Cond. umho/cm	pH	Acidity mg/l as $CaCO_3$	Alkalinity mg/l as $CaCO_3$	Sulfate mg/l	Tracer $Br^{-}F^{-}I^{-}$
4/3/79		low	7.5	1450	5.1		3	1540	- -
6/11/79	4:20 pm			2010	4.90	30.6	4.5		
6/16/79	11:30	dry							
6/22/79		dry							
6/29/79		dry							
7/7/79		dry							
7/14/79		dry							
7/23/79		dry							
7/30/79	1:45	very slow	19	2285	4.18	51	0	1525	- -
8/6/79		dry							
8/13/79	1:10	very slow	15	1950	4.7	23.8	0.5		-
8/22/79	1:40	very slow	15	2080	4.5	28.8	0		
8/28/79	1:55	slow	19.5	1940	6.5	3.8	11	1210	
9/4/79	1:45	very slow	20	2210	5.8	10	11		
9/10/79	2:00	dry							
9/17/79	3:00	dry							
9/24/79	1:17	very slow	17	2040	4.5	10.3	0	1380	- -
10/1/79	1:19	very slow	18	1920	6.5	4	11		- - -
10/9/79	10:52	very slow	15	2000	7.9	2.8	187		- -
10/15/79		dry							
10/23/79		dry							
10/29/79		dry							
11/5/79		dry							
11/12/79		dry							
11/18/79		dry							
11/26/79	11:53	very slow	11	1720	3.66	97	0	1050	- -
12/3/79		dry							
12/10/79		dry							
12/17/79		dry							
12/24/79		dry							
1/2/80		dry							

Bedway Site, Fairview, Ohio
Sample Location # 14 (cont.)

Date & Time of Collection		Q	Temp. ^{o}C	S. Cond. umho/cm	pH	Acidity mg/l as $CaCO_3$	Alkalinity mg/l as $CaCO_3$	Sulfate mg/l	Tracer $Br^-F^-I^-$
1/8/80		dry							
1/14/80	11:38	fast	1.0	1998	7.2	2.8	92.0		
1/22/80		dry							
2/1/80		dry							
2/4/80		dry							
2/11/80		dry							
2/19/80		unfrozen, no flow							
2/25/80		dry							
3/3/80		dry							
3/10/80	10:15	medium	2.0	1920	5.62	6	20		
3/17/80	11:07	fast	6.0	1640	3.3	39	0		
3/23/80	12:54	fast	4.0	1880	5.18	7	10		
3/31/80	1:00 pm	medium	6.0	1950	4.60	20	8	1120	- -
4/7/80	12:33	med. fast	8.0	2090	5.30	6	4		
4/14/80	4:35	very slow		1230	4.49	37	0		- -
4/21/80		no flow							
4/28/80		no flow							
5/5/80		dry							
5/12/80		not collected							
5/19/80		no flow							
5/29/80		dry							
6/3/80		dry							
6/9/80		dry							
6/18/80		dry							
6/24/80		dry							
7/3/80		dry							
7/9/80		dry							
7/15/80		dry							
7/25/80		dry							
8/8/80		dry							
8/14/80		dry							

Bedway Site, Fairview, Ohio
Sample Location # 14 (cont.)

Date & Time of Collection	Q	Temp. °C	S. Cond. umho/cm	pH	Acidity mg/l as $CaCO_3$	Alkalinity mg/l as $CaCO_3$	Sulfate mg/l	Tracer $Br^-F^-I^-$
8/22/80	dry							
8/28/80	dry							
9/7/80	dry							
9/16/80	dry							
9/22/80	dry							
10/1/80	dry							
10/6/80	dry							
10/15/80	dry							
10/20/80	dry							
10/27/80	dry							
11/3/80	dry							
11/10/80	dry							
11/19/80	dry							
11/24/80	dry							
12/1/80	dry							
12/8/80	dry							
12/22/80	dry							
12/29/80	dry							
1/6/81	frozen							
1/19/81	frozen							
1/26/81	dry							
2/13/81	frozen							
2/17/81	dry							
2/25/81	dry							
3/4/81	dry							
3/11/81	dry							
3/16/81	dry							
3/23/81	dry							
4/3/81	dry							
4/19/81	dry							

Bedway Site, Fairview, Ohio
Sample Location # 14 (cont.)

Date & Time of Collection	Q	Temp. °C	S. Cond. umho/cm	pH	Acidity mg/l as $CaCO_3$	Alkalinity mg/l as $CaCO_3$	Sulfate mg/l	Tracer $Br^-F^-I^-$
4/25/81	dry							
5/1/81	dry							
5/9/81	dry							
5/15/81	dry							
5/24/81	dry							
5/31/81	dry							
6/7/81	dry							
6/16/81	dry							
6/26/81	dry							

Bedway Site, Fairview, Ohio
Sample Location # 15

Date & Time of Collection		Q	Temp. ^oC	S. Cond. umho/cm	pH	Acidity mg/l as $CaCO_3$	Alkalinity mg/l as $CaCO_3$	Sulfate mg/l	Tracer		
									Br^-	F^-	I^-
4/3/79		low	9.6	1570	6.4	0	74	1371	-		-
6/11/79	4:30 pm	low		1850	7.05	16.9	101.5				
6/16/79	11:30 pm	very low	24	2750	7.15	0	110.0		-		-
6/22/79		dry									
6/29/79		dry									
7/7/79		dry									
7/14/79		dry									
7/23/79		dry									
7/30/79		dry									
8/6/79		dry									
8/13/79	1:00	very slow	21.5	1820	7.8	0	93.5				
8/22/79	1:40	very slow	22	1980	7.6 (field) 6.5 (lab)		126.0				
8/28/79	1:48	slow	26	1580	8.1	0	105.5	835	-		-
9/4/79		very slow	25	2200	7.4	4	99				
9/10/79	1:48	slow	22	2460	8.5	4	115.5				
9/17/79	3:05	barely	21	2200	7.9	0	104				
9/24/79	1:12	very slow	18	1960	7.8	0	110	1200	-		-
10/1/79	1:15	very slow	19.5	1820	8.4	3	93.5		-	-	-
10/9/79	10:48	slow	14	1880	7.7	0	97		-		-
10/15/79	12:21	slow	10	2080	8.1	0	95				
10/23/79	10:45	slow	14	2240		0	115		-		-
10/29/79	12:25	slow	11	2080	7.7	2	105	1610	-		-
11/5/79	12:26	slow	9	2260	7.9	3	113				
11/12/79	12:10	very slow	6.5	1990	7.9	2	108		-		-
11/18/79	1:45	very slow	9.5	2200	7.8	0	118		-		T
11/26/79	11:48	slow	11	1370	7.3	0	104	630	-		-
12/3/79	12:35	slow	0	2110	7.9	0	121		-		-
12/10/79	2:15	slow	4	2080	7.9	0	111				
12/17/79		frozen-no flow									
12/24/79	11:35	slow	8	1480	8.2	0	102	1070			

Bedway Site, Fairview, Ohio
Sample Location # 15 (cont.)

Date & Time of Collection		Q	Temp. ^{o}C	S. Cond. umho/cm	pH	Acidity mg/l as $CaCO_3$	Alkalinity mg/l as $CaCO_3$	Sulfate mg/l	Tracer $Br^-F^-I^-$
1/2/80	11:29	slow	1.5	1690	7.8	0	130		- -
1/8/80		frozen							
1/14/80	11:34	fast	1.0	1820	7.7	1.2	150		
1/22/80	3:54	slow.	2.0		8.0	1.6	150		- -
2/1/80		frozen							
2/4/80		frozen							
2/11/80		frozen							
2/19/80	4:08	medium	0	1010	7.7	1.6	55		
2/25/80	11:04	very slow	1.0	2220	8.2	1.6	153		- -
3/3/80		frozen							
3/10/80	10:45	med. slow	0	2040	8.1	10	130		
3/17/80	11:02	fast	6.0	1370	8.2	2.4	135		
3/23/80	12:51	medium	7.0	1730	8.2	0	122		
3/31/80	12:55 pm	med. fast	10.5	1760	7.30	3	107	800	- -
4/7/80	12:29	slow	11	2100	7.00	0	95		
4/14/80	4:40	med. slow		1080	7.10	0	86		
4/21/80	1:25	very slow	18	2150	6.91	0	95		
4/28/80	1:15	very slow	14	2250	8.0	4	103	1280	
5/5/80	1:59	very slow	22	2390	7.27	2	121		- -
5/12/80		not collected							
5/19/80	3:45	slow	20.5	1600	7.62	2	78		- -
5/29/80	3:05	very slow		24.0	7.28	1	95	1460	- -
6/3/80	1:55	slow	23	1580	7.23	1	87		- -
6/9/80	1:35 pm	very slow	20.5	2050	7.52	0	90		- -
6/18/80	1:00	very slow	25.5	2340	7.72	0	129		- -
6/24/80	7:30	very slow	22	2920	7.64	0	95	1610	- -
7/3/80		dry							
7/9/80	11:00	very slow	21	2460	7.41	2	87		- -
7/15/80		dry							
7/25/80	8:00	very slow	23	2280	7.88	0	87		- -
8/8/80	11:20	very slow	25	2180	8.08	0	78	1150	- -

Bedway Site, Fairview, Ohio
Sample Location # 15 (cont.)

Date & Time of Collection	Q	Temp. °C	S. Cond. umho/cm	pH	Acidity mg/l as $CaCO_3$	Alkalinity mg/l as $CaCO_3$	Sulfate mg/l	Tracer $Br^-F^-I^-$
8/14/80 9:20	very slow		1980	7.69	0	87		- -
8/22/80 1:00	very slow		1710	7.78	2	87		- -
8/28/80 4:00	very slow	25.5	2400	7.42	0	87		- -
9/7/80 9:25	very slow	20	2400	7.65	0	78	1380	- -
9/16/80 4:18	very slow		2680	7.87	2	60		- -
9/22/80 1:34	very slow	23	2820	7.71	0	115		- -
10/1/80	dry							
10/6/80	dry							
10/15/80	dry							
10/20/80 1:14	very slow	10	2540	7.82	0	103		- -
10/27/80 1:53	very slow	9	1890	7.63	0	95	1340	- -
11/3/80	dry							
11/10/80	dry							
11/19/80 2:40	slow	4	1890	7.49	0	43		- -
11/24/80 1:50	slow	6	880	7.51	0	51		- -
12/1/80 1:50	med. slow	6.5	1500	7.61	0	98	890	- -
12/8/80 1:50	slow	9.5	1520	7.78	0	103		- -
12/22/80	frozen							
12/29/80	frozen							
1/6/81	frozen							
1/19/81	frozen							
1/26/81 12:56	med. fast	1.0	810	7.75	0	70	500	- -
2/13/81	frozen							
2/17/81 4:15	slow	6.0	1050	7.60	0	103		- -
2/25/81 4:40	fast		1225	8.01	0	145	760	- -
3/4/81 12:43	slow	4.0	1720	7.51	2.0	126		- -
3/11/81 12:50	slow	4.0	1750	7.60	2.0	128		- -
3/16/81 2:05	slow		1800	7.70	0.8	102		- T
3/23/81 2:19	slow	8.0	1950	7.45	0	113	1260	- -

Bedway Site, Fairview, Ohio
Sample Location # 15 (cont.)

Date & Time of Collection	Q	Temp. °C	S. Cond. umho/cm	pH	Acidity mg/l as $CaCO_3$	Alkalinity mg/l as $CaCO_3$	Sulfate mg/l	Tracer $Br^-F^-I^-$
4/3/81 4:56	very slow	12.0	2050	7.45	0	140		- -
4/19/81 12:00	medium	11.0	1540	7.50	1.2	140		- -
4/25/81 11:40 am	very slow	9.0	1680	7.52	1	100	1030	- -
5/1/81 6:37	slow	5.5	1860	7.55	0	130		- T
5/9/81 7:21	slow	6.0	2100	7.7	0	140		- -
5/15/81 11:29	very slow		1300	7.80	2.20	144		- -
5/24/81 12:20	very slow		2320	7.50	0	136		- -
5/31/81 12:52	very slow	21.0	1700	7.50	0	120		- T
6/7/81 12:25	very slow	22.5	1490	7.60	0	125		- -
6/16/81 11:15	very slow	24.0	1550	7.65	2.60	126		- -
6/26/81 6:51	fast	26.0	1400	7.70	0	121		- T

Bedway Site, Fairview, Ohio
Sample Location # 16

Date & Time of Collection	Q	Temp. °C	S. Cond. umho/cm	pH	Acidity mg/l as $CaCO_3$	Alkalinity mg/l as $CaCO_3$	Sulfate mg/l	Tracer $Br^-F^-I^-$
4/5/79			2750	3.2	276	0	2100	- - -
6/13/79	1.5in^3/sec	21	3610	2.68	849	0		
6/16/79 2 pm	very low	18	3480	2.60	486	0		
6/22/79	dry							
6/29/79	little	20	3580	2.75	854	0	2375	- - -
7/7/79	dry							
7/14/79	dry							
7/23/79	dry							
7/30/79	dry							
8/6/79	dry							
8/13/79	very slow	18	3210	2.65	759	0		
8/22/79	(no sample collected)							
8/28/79 3:05	very slow	20	3100	2.50	705	0	2010	- - -
9/4/79 3:00	dry							
9/10/79 3:00	dry							
9/17/79 3:00	dry							
9/24/79 1:10	very slow	16.5	3120	2.68	877	0	2275	- - -
10/1/79 1:30	very slow	18	2900	2.70	705	0		-
10/9/79	slow	13	2920	2.65	674	0		- - -
10/15/79 1:05	very slow	10.5	2990	2.80	759	0		- -
10/23/79 11:00	dry							
10/29/79	dry							
11/5/79	dry							
11/12/79 12:50	very slow	9	3150	3.06	911	0		- - -
11/18/79	dry							
11/26/79	dry							
12/3/79	frozen-no flow							
12/10/79	dry							
12/17/79 2:00	dry							
12/24/79	dry							
1/2/80	dry							

Bedway Site, Fairview, Ohio
Sample Location # 16 (cont.)

Date & Time of Collection	Q	Temp. °C	S. Cond. umho/cm	pH	Acidity mg/l as $CaCO_3$	Alkalinity mg/l as $CaCO_3$	Sulfate mg/l	Tracer $Br^-F^-I^-$
1/8/80	no flow							
1/14/80	no flow							
1/22/80	dry							
2/1/80	frozen							
2/4/80	frozen							
2/11/80	frozen							
2/19/80	unfrozen, no flow							
2/23/80	dry							
3/3/80	frozen							
3/10/80	no flow							
3/17/80	no flow							
3/23/80	dry							
3/31/80	dry							
4/7/80	no flow							
4/14/80	no flow							
4/21/80	no flow							
4/28/80	no flow							
5/5/80	dry							
5/12/80	not collected							
5/19/80	no flow							
5/29/80	dry							
6/3/80	dry							
6/9/80	no flow							
6/18/80	dry							
6/24/80	dry							
7/3/80	dry							
7/9/80	dry							
7/15/80	dry							
7/25/80	dry							
8/8/80	dry							
8/14/80	dry							

Bedway Site, Fairview, Ohio
Sample Location # 16 (cont.)

Date & Time of Collection	Q	Temp. ^{o}C	S. Cond. umho/cm	pH	Acidity mg/l as $CaCO_3$	Alkalinity mg/l as $CaCO_3$	Sulfate mg/l	Tracer $Br^{-}F^{-}I^{-}$
8/22/80	dry							
8/28/80	dry							
9/7/80	dry							
9/16/80	dry							
9/22/80	dry							
10/1/80	dry							
10/6/80	dry							
10/15/80	dry							
10/20/80	dry							
10/27/80	dry							
11/3/80	dry							
11/10/80	dry							
11/19/80	dry							
11/24/80	dry							
12/1/80	dry							
12/8/80	dry							
12/22/80	frozen							
12/29/80	dry							
1/6/81	frozen							
1/19/81	frozen							
1/26/81	dry							
2/13/81	frozen							
2/17/81	dry							
2/25/81	dry							
3/4/81	dry							
3/11/81	dry							
3/16/81	dry							
3/23/81	dry							
4/3/81	dry							
4/19/81	dry							

Bedway Site, Fairview, Ohio
Sample Location # 16 (cont.)

Date & Time of Collection	Q	Temp. °C	S. Cond. umho/cm	pH	Acidity mg/l as $CaCO_3$	Alkalinity mg/l as $CaCO_3$	Sulfate mg/l	Tracer $Br^-F^-I^-$
4/25/81	dry							
5/1/81	dry							
5/9/81	dry							
5/15/81	dry							
5/24/81	dry							
5/31/81	dry							
6/7/81	dry							
6/16/81	dry							
6/26/81	dry							

Bedway Site, Fairview, Ohio
Sample Location # 17

Date & Time of Collection	Q	Temp. oC	S. Cond. umho/cm	pH	Acidity mg/l as $CaCO_3$	Alkalinity mg/l as $CaCO_3$	Sulfate mg/l	Tracer $Br^-F^-I^-$
4/5/79			1910	3.6	156	0	1350	- - -
6/13/79	3in^3/sec	21	2200	3.32				- - -
6/16/79 2:20	low	21.5	2220	3.30	810	0		
6/22/79 3:00		20	2200	3.70	188	0		
6/29/79 4:10	very little	21.5	2300	3.75	183	0	1400	- - -
7/7/79 5:45	slow	21	2310	3.20	189	0		
7/14/79 4:25	slow	24.5	2390	3.70	184	0		
7/23/79 3:00	very little	22	2710	3.15	149	0		
7/30/79 3:20	slow	18	2300	3.25	265	0	1460	- - -
8/6/79 1:50	very slow	25	2520	3.36	173	0		
8/13/79 2:20	slow	16	2070	3.21	158	0		
8/22/79 2:40	slow	16	2000	3.30	272	0		
8/28/79 2:35	slow	20	1720	3.30	231	0	1020	- -
9/4/79 2:20	very slow	23	1990	3.20	146	0		
9/10/79 2:15	very slow	22	2180	3.18	184	0		- -
9/17/79 3:00	very slow	21	2120	3.18	192	0		
9/24/79 12:35	slow	18	1960	3.30	182	0	1280	- - -
10/1/79 12:25	very slow	17.5	1750	3.48	132	0		- - -
10/9/79 10:15	slow	14	1700	3.62	96	0		- - T
10/15/79 12:30	very slow	15		3.31	127	0		- - T
10/23/79	dry							
10/29/79 12:30	very slow	13.5	1900	3.58	163	0	1420	- - T
11/5/79 12:20	very slow	12	2260	3.25	170	0		-
11/12/79 12:00	very slow	12	1950	3.68	157	0		- - -
11/18/79 2:35	very slow	11.5	2200	3.38	178	0		- - T
11/26/79 11:45	medium	10	1560	3.86	106	0	900	- - T
12/3/79 12:30	very slow	9.5	2040	3.65	141	0		- - T
12/10/79 12:30	slow	7	2100	3.5	166	0		
12/17/79 12:45	very slow	6.5	1790	3.52	135	0		
12/24/79 12:00	very slow	8	1510	3.43	139	0	1330	- - -

Bedway Site, Fairview, Ohio
Sample Location # 17 (cont.)

Date & Time of Collection		Q	Temp. ^{o}C	S. Cond. umho/cm	pH	Acidity mg/l as $CaCO_3$	Alkalinity mg/l as $CaCO_3$	Sulfate mg/l	Tracer $Br^-F^-I^-$
1/2/80	11:00	very slow	1.0	1450	3.49	134	0		
1/8/80	2:30	very slow	6.0	1710	3.60	155	0		
1/14/80	11:03	very slow	6.0	1720	3.65	105	0		
1/22/80	3:30	very slow	5.0		3.89	93	0		-
2/1/80		frozen							-
2/4/80		frozen							
2/11/80		frozen							
2/19/80	3:20	med. good	2.0	560	5.60	1.6	4.8		
2/25/80		dry							
3/3/80		frozen							
3/10/80		no flow							
3/17/80		no flow							
3/23/80		dry							
3/31/80		dry							
4/7/80		dry							
4/14/80	4:05 pm	medium		1110	4.13	76	0		
4/21/80		no flow							
4/28/80		no flow							
5/5/80		dry							
5/12/80		not collected							
5/19/80	3:20 pm	very slow	16.5	1420	3.98	52	0		- -
5/29/80		dry							
6/3/80	1:35 pm	very slow	17	1510	3.49	149	0		- -
6/9/80		no flow							
6/18/80		dry							
6/24/80		dry							
7/3/80		dry							
7/9/80		dry							
7/15/80		dry							
7/25/80		dry							
8/8/80		dry							
8/14/80		dry							
8/22/80	12:40	slow		1400	4.42	26	0		- -

Bedway Site, Fairview, Ohio
Sample Location # 17 (cont.)

Date & Time of Collection	Q	Temp. °C	S. Cond. umho/cm	pH	Acidity mg/l as $CaCO_3$	Alkalinity mg/l as $CaCO_3$	Sulfate mg/l	Tracer $Br^-F^-I^-$
8/28/80	dry							
9/7/80	dry							
9/16/80	dry							
9/22/80	dry							
10/1/80	dry							
10/6/80	dry							
10/15/80	dry							
10/20/80	dry							
10/27/80	dry							
11/3/80	dry							
11/10/80	dry							
11/19/80	dry							
11/24/80	dry							
12/1/80	dry							
12/8/80	dry							
12/22/80	dry							
12/29/80	dry							
1/6/81	frozen							
1/19/81	frozen							
1/26/81	dry							
2/13/81	frozen							
2/17/81	dry							
2/25/81	dry							
3/4/81	dry							
3/11/81	dry							
3/16/81	dry							
3/23/81	dry							
4/3/81	dry							
4/19/81	dry							
4/25/81	dry							

Bedway Site, Fairview, Ohio
Sample Location # 17 (cont.)

Date & Time of Collection	Q	Temp. ^oC	S. Cond. umho/cm	pH	Acidity mg/l as $CaCO_3$	Alkalinity mg/l as $CaCO_3$	Sulfate mg/l	Tracer $Br^-F^-I^-$
5/1/81	dry							
5/9/81	dry							
5/15/81	dry							
5/24/81	dry							
5/31/81	dry							
6/7/81	dry							
6/16/81	dry							
6/26/81	dry							

Bedway Site, Fairview, Ohio
Sample Location # 18

Date & Time of Collection	Q	Temp. °C	S. Cond. umho/cm	pH	Acidity mg/l as $CaCO_3$	Alkalinity mg/l as $CaCO_3$	Sulfate mg/l	Tracer		
								Br-	F-	I-
4/5/79	very low		2510	3.25	215	0	1750	-		-
6/13/79	very low	16	2680	4.2	42	0		-		-
6/16/79 2:10	very low	16	2540	3.7	68	0		-		-
6/22/79	no flow									
6/29/79 4:40	little	16.5	2680	5.20	0.4		1745			
7/7/79 5:30	very low	25	2490	3.95	42					
7/16/79 5:00	very low	18	2550	5.70	4.5					
7/23/79	dry									
7/30/79 3:50	very slow	24	2510	6.4 (field) 5.4 (lab)	0	22	1625			-
8/6/79 2:20	very slow		2520	6.7 (field) 5.82 (lab)	35.4	44				-
8/13/79 2:45	very slow	21.5	1710	5.6 (field) 3.5 (lab)	31.1	11		-		-
8/22/79 3:10	very slow	21	1760	5.3 (field) 4.2 (lab)	6.2	11				
8/28/79 2:50	slow	23	2020	4.3	43.8	0	1165	-		-
9/4/79 2:35	slow	24.5	2500	4.3	56.9	0				
9/10/79 2:30	very slow	23.5	2500	3.42	58.4	0		-		-
9/17/79 3:18	very slow	24	2500	3.56	73.4	0				
9/24/79 12:50	slow	21	2310	3.30	56.1	0	1600	-		-
10/1/79 12:55	slow	21	2120	3.35	52.9	0		-	-	-
10/9/79 10:35	medium	15	2310	3.38	43.2	0		-		-
10/15/79 12:50	slow	16		3.5	46.6	0		-		T
10/23/79 10:45	slow	13.5	2340	3.60	41.5	0		-		T
10/29/79 12:45	slow	16	2190	3.70	52.8	0	1680	-		T
11/5/79 12:45	slow	11.5	2520	3.52	46.7	0			-	
11/12/79 12:25	slow	11	2460	3.85	47.5	0		-	-	T
11/18/79 3:10	slow	12.5	2580	3.40	56.8	0		-		-
11/26/79 1:15	very slow	10.5	2430	4.40	6.1	0	1540	-		T
12/3/79 1:00	very slow	8	2320	3.92	36.4	0				T

Bedway Site, Fairview, Ohio
Sample Location # 18 (cont.)

Date & Time of Collection	Q	Temp. °C	S. Cond. umho/cm	pH	Acidity mg/l as $CaCO_3$	Alkalinity mg/l as $CaCO_3$	Sulfate mg/l	Tracer $Br^-F^-I^-$
12/10/79 12:58	very slow	6	2380	3.52	36.4	0		
12/17/79 1:35	very slow	4	2250	3.88	18.1	0		
12/24/79 12:30	very slow	10.5	1700	4.05	10.3	0	1530	- - -
1/2/80 11:30	slow	5	1780	4.80	0	14.9		
1/8/80 3:20	very slow	5	2010	4.95	0	19.2		
1/14/80 11:45			2340	5.39	2	43.5		
1/22/80 4:10	slow	5		5.70	0	55.2	1560	- -
2/1/80 2:15	very slow	3.0	2490	6.0	0	75		- T
2/4/80 10:35	very slow	3.0	2510	5.59	0	54.5		- T
2/11/80 10:30	very slow	3.0	2580	7.5	0	55		
2/19/80 3:00 pm	very slow	12.0	2420	6.8	5	41		
2/25/80 11:30	very slow	5.0	2340	5.5	3	30	1470	- -
3/3/80	frozen							
3/10/80 10:55	very slow	5.0	2420	6.7	3	102		
3/17/80 10:55	slow	6.0	2000	6.8	0	55		
3/23/80 1:25 pm	slow	7.5	2020	5.57	4	38		
3/31/80 1:20	slow	8.5	2300	5.45	6	38	1260	- -
4/7/80 12:50	very slow	8.5	2370	5.35	2	35		
4/14/80 4:00	very slow		2310	7.00	0	35		
4/21/80 1:00	very slow	11.0	2400	5.75	0	26		
4/28/80 12:55	very slow	14	2410	7.10	0	43	1600	- -
5/5/80 1:39	very slow	14	2690	6.45	2	43		- -
5/12/80	not collected							
5/19/80 3:10	very slow	20	1980	6.58	0	35		- -
5/29/80 2:40	very slow	25	2400	6.26	0	44	1400	- T
6/3/80 1:25	very slow	20	1760	6.14	0	26		- T
6/9/80 1:08	very slow	17.5	2120	6.42	5	26		- -
6/18/80 12:43	very slow	25	2360	6.31	0	52		- -
6/24/80 6:00	slow	22	2590	6.22	0	36	1380	- T
7/3/80 5:00	very slow	29	2590	6.33	0	30		- -
7/9/80 10:30	very slow	22	2550	6.12	1	30		- -

Bedway Site, Fairview, Ohio
Sample Location # 18 (cont.)

Date & Time of Collection		Q	Temp. °C	S. Cond. umho/cm	pH	Acidity mg/l as $CaCO_3$	Alkalinity mg/l as $CaCO_3$	Sulfate mg/l	Tracer $Br^-F^-I^-$
7/15/80		dry							
7/25/80		dry							
8/8/80	10:35 am	very slow	24	2400	6.81	2	23	1330	- -
8/14/80	8:40 pm	very slow		2370	6.20	1	10		- -
8/22/80	12:35	very slow		2430	7.0	0	35		- -
9/7/80	9:00	very slow	18	2700	6.44	0	70	1760	- -
9/16/80		dry							
9/22/80		dry							
10/1/80		dry							
10/6/80		dry							
10/15/80		dry							
10/20/80		stagnant							
10/27/80		dry							
11/3/80		dry							
11/10/80		dry							
11/19/80		dry							
11/24/80		dry							
12/1/80		dry							
12/8/80		dry							
12/22/80		frozen							
12/29/80		dry							
1/6/81		frozen							
1/19/81		frozen							
1/26/81		dry							
2/13/81		frozen							
2/17/81		dry							
2/25/81		dry							
3/4/81		dry							
3/11/81		dry							
3/16/81		dry							

Bedway Site, Fairview, Ohio
Sample Location # 18 (cont.)

Date & Time of Collection	Q	Temp. ^oC	S. Cond. umho/cm	pH	Acidity mg/l as $CaCO_3$	Alkalinity mg/l as $CaCO_3$	Sulfate mg/l	Tracer $Br^-F^-I^-$
3/23/81	dry							
4/3/81	dry							
4/19/81	dry							
4/25/81	dry							
5/1/81	dry							
5/9/81	not sampled							
5/15/81	not sampled							
5/24/81	not sampled							
5/31/81	not sampled							
6/7/81	not sampled							
6/16/81	not sampled							
6/26/81	not sampled							

Bedway Site, Fairview, Ohio
Sample Location # 19

Date & Time of Collection	Q	Temp. ^oC	S. Cond. umho/cm	pH	Acidity mg/l as $CaCO_3$	Alkalinity mg/l as $CaCO_3$	Sulfate mg/l	Tracer $Br^-F^-I^-$
4/5/79 12 pm			1910	3.6	156	0	1350	- - -
6/7/79	low		2130	3.3	230	0		- - -
6/13/79	low	21	2190	3.32	230	0		
6/16/79 2:25	very low	22	2280	3.3	170	0		
6/22/79 3:00	low	18	2350	3.32	203	0		
6/29/79 4:10	very low	21	2410	3.35	198	0	1485	
7/7/79 5:50	low	17	2310	3.2	184	0		
7/16/79 4:30	dry							
7/23/79	dry							
7/30/79 3:30	medium	18	2310	3.18	236	0	1550	- - -
8/6/79 1:55	very slow	24	2550	3.26	275	0		
8/13/79 2:25	slow	15	2100	3.35	134	0		
8/22/79 2:50	medium	17	1980	3.70	123	0		
8/28/79 2:40	slow	18	2010	3.25	136	0	1205	- - -
9/4/79 2:25	slow	23.5	2090	3.45	115	0		
9/10/79 2:10	dry							
9/17/79 3:05	very slow	25	2190	4.2	49.4	0		
9/24/79 12:30	slow	19	2000	3.55	138	0	1350	
10/1/79 12:30	slow	18.5	1900	3.44	136	0		- -
10/9/79 10:20	slow	15	1900	3.44	115	0		- - T
10/15/79 12:35	slow	15.5	1910	3.45	113.5	0		- - T
10/23/79 10:30	very slow	13	2000	4.18	70.1	0		- - T
10/29/79	dry							
11/5/79	dry							
11/12/79 12:05	slow	12	2100	3.68	161	0		T T
11/18/79	dry							
11/26/79 1:50	medium	12	1920	3.42	147	0	1200	- -
12/3/79	frozen-no flow							
12/10/79	frozen							
12/17/79 1:00	very slow	5	1960	3.52	137	0		-

Bedway Site, Fairview, Ohio
Sample Location # 19 (cont.)

Date & Time of Collection		Q	Temp. ^oC	S. Cond. umho/cm	pH	Acidity mg/l as $CaCO_3$	Alkalinity mg/l as $CaCO_3$	Sulfate mg/l	Tracer $Br^-F^-I^-$
12/24/79	12:05	slow	9	1590	3.45	134	0	1400	- - -
1/2/80		dry							
1/8/80		frozen							
1/14/80	11:11	medium	9.0	2000	3.60	104	0		- - -
1/22/80	3:40	slow	5.0		4.29	91	0		- - -
2/1/80		frozen							
2/4/80		frozen							
2/11/80		frozen							
2/19/80		frozen							
2/25/80	11:00	slow	8.0	1820	3.81	75	0	1110	- - -
3/3/80		frozen							
3/10/80	10:30	med. slow	6.0	1820	3.69	117	0		
3/17/80	10:30 am	medium	6.0	1780	3.70	121	0		
3/23/80	1:00 pm	medium	7.0	1690	3.70	80	0		
3/31/80	1:00 pm	medium	7.0	1700	3.61	99	0	900	- - -
4/7/80	12:30 pm	very slow	8.5	1790	3.80	100	0		
4/14/80	4:08	medium		1370	3.55	136	0		
4/21/80	1:08	very slow	15	1805	3.92	60	0		
4/28/80		no flow							
5/5/80	1:44	dry							
5/12/80		not collected							
5/19/80	3:23	medium	11.0	1620	3.61	102	0		- - -
5/29/80		dry							
6/3/80	1:40	fast	13	1650	3.47	110	0		- - -
6/9/80	1:20	slow	13	1810	3.54	113	0		- - -
6/18/80	12:50	very slow	17	2000	3.69	122	0		- - -
6/24/80	6:10	very slow	20	2170	4.22	76	0	1200	- - T
7/3/80		dry							
7/9/80	10:40	very slow	20	1920	4.40	90	0		- - T
7/15/80		dry							
7/25/80		dry							
8/8/80	11:00	very slow	18	1900	3.61	85	0	960	- - -

Bedway Site, Fairview, Ohio
Sample Location # 19 (cont.)

Date & Time of Collection		Q	Temp. °C	S. Cond. umho/cm	pH	Acidity mg/l as $CaCO_3$	Alkalinity mg/l as $CaCO_3$	Sulfate mg/l	Tracer $Br^-F^-I^-$
8/14/80	8:50 pm	slow		1610	3.91	83	0		- -
8/22/80	12:44	slow		1600	3.56	80	0		- -
8/28/80	3:36	very slow	20	1880	3.44	92	0		- - T
9/7/80	9:05	very slow	18	1995	5.73	3	6.3	1200	- - -
9/16/80		dry							
9/22/80		dry							
10/1/80		dry							
10/6/80		dry							
10/15/80		dry							
10/20/80		dry							
10/27/80		dry							
11/3/80		dry							
11/10/80		dry							
11/19/80		dry							
11/24/80		dry							
12/1/80		dry							
12/8/80		dry							
12/22/80		dry							
12/29/80		dry							
1/6/81		frozen							
1/19/81		frozen							
1/26/81	1:25	slow		1610	3.50	116	0	1020	- - -
2/13/81		frozen							
2/17/81	4:00	med. slow	8.0	1340	3.70	141	0		- - -
2/25/81	5:08	very slow	5.0	1330	3.75	98	0	880	- - -
3/4/81	1:08	slow		1530	4.31	115	0		- - -
3/11/81	1:35	slow	6.0	1600	3.80	82	0		- - -
3/16/81	2:33	very slow		1760	3.80	112	0		- - -
3/23/81	32:54	very slow		1750	4.19	120	0	1240	- - T
4/3/81		dry							

Bedway Site, Fairview, Ohio
Sample Location # 19 (cont.)

Date & Time of Collection		Q	Temp. °C	S. Cond. umho/cm	pH	Acidity mg/l as $CaCO_3$	Alkalinity mg/l as $CaCO_3$	Sulfate mg/l	Tracer $Br^-F^-I^-$
4/19/81	12:20	med. fast		1370	3.70	112	0		- - T
4/25/81	11:57	slow	9.0	1450	3.53	99	0	900	- - T
5/1/81	7:03	slow	6.0	1550	3.90	90	0		- - -
5/9/81	7:55	very slow		1620	4.08	83	0		- - -
5/15/81	11:55	slow		1500	3.90	93	0		- - T
5/24/81		dry							
5/31/81	1:11	slow	11.0	1550	3.70	77	0		- - T
6/7/81	12:38	slow	12.5	1540	3.92	78	0		- - T
6/16/81	11:36	slow	13.0	1360	3.70	70	0		- - T
6/26/81	7:04	medium	21.0	1300	3.85	62	0		- - T

Bedway Site, Fairview, Ohio
Sample Location # 20

Date & Time of Collection		Q	Temp. °C	S. Cond. umho/cm	pH	Acidity mg/l as $CaCO_3$	Alkalinity mg/l as $CaCO_3$	Sulfate mg/l	Tracer Br^-	F^-	I^-
4/5/79	1 pm			1420	8.1	0		716	-		-
6/13/79		7½ cfs	15.5	1690	7.75	0	171		-		-
6/16/79	2:30	70.1 cfs	17	1680	8.0	0	170.5				
6/22/79	3:15		17	1610	7.65	0	220				
6/29/79	4:23	low	17	1610	8.0	0	225	680			
7/7/79	5:50	no flow									
7/16/79	4:40	very low	21	1600	8.1	0	215				
7/23/79	3:20	very slow	15.5	1750	8.2		214.5				
7/30/79	3:40	slow	17.5	1610	7.7 (field) 6.4 (lab)	1.5	187	775		-	
8/6/79		very slow		1800	7.7 (field) 6.45 (lab)	0	209				
8/13/79	2:35	slow	12.5	1490	8.1	0	148.5				
8/22/79	2:45	slow	16	1480	7.8 (field) 6.65 (lab)	0	187				
8/28/79	2:45	slow	19	1450	8.0	0	137.5	710	-		-
9/4/79	2:30	very slow	21.5	1520	6.92	5.4	203.5				
9/10/79	2:25	very slow	18	1560	8.1	4.0	192.5				
9/17/79	3:10	very slow	19	1560	8.0 (field) 6.6 (lab)	3.2	193				
9/24/79	12:45	slow	14	1480	8.2	4.0	161	712			
10/1/79	12:40	slow	16.5	1400	8.5	3.6	155		-		-
10/9/79	10:25	slow	12.5	1420	8.4	0	187		-	-	-
10/15/79	12:40	slow	10	1480	8.7	0	173		-	-	-
10/23/79	10:35	very slow	14	1480	8.2	3.6	185		-		-
10/29/79	12:38	very slow	10.5	1480	8.4	1.8	187	710	-	-	-
11/5/79	12:30	slow	7.5	1530	8.4	3.5	192			-	
11/12/79	12:15	slow	8	1490	8.2	0	162		T	-	T
11/18/79	2:50	very slow	10	1550	8.2	2	182		T	-	-
11/26/79	1:58	med. slow	10	1330	7.8	0	115	580	-		-
12/3/79	12:45	very slow	1.0	1420	8.5	1.6	178			-	

Bedway Site, Fairview, Ohio
Sample Location # 20 (cont.)

Date & Time of Collection		Q	Temp. °C	S. Cond. umho/cm	pH	Acidity mg/l as $CaCO_3$	Alkalinity mg/l as $CaCO_3$	Sulfate mg/l	Tracer $Br^-F^-I^-$
12/10/79	12:45	very slow	2.5	1480	8.4	0	185		
12/17/79	1:15	very slow	0	1400	8.5	0	123		- -
12/24/79	12:15	slow	8	1110	8.4	0	194	730	
1/2/80	11:15 am	very slow	1.5	1130	8.2	0	234		- -
1/8/80	2:50	very slow	1	1220	8.6	0.8	240		
1/14/80	11:20	slow	6	1495	8.1	0	145		
1/22/80	3:50	very slow	2.0		8.3	0	210		- -
2/1/80		frozen							
2/4/80		frozen							
2/11/80		frozen							
2/19/80		frozen							
2/25/80	11:15	very slow	2.0	1460	8.0	4	150	640	
3/3/80		frozen							
3/10/80	10:40	slow	4.0	1490	8.0	4	82		
3/17/80	10:10	med. slow	7.0	1290	8.0	2	110		- -
3/23/80	1:10	very slow	7.5	1400	7.22	0	104		
3/31/80	1:05	slow	9.5	1410	7.11	5	104	520	
4/7/80	12:35	very slow	9.5	1500	7.10	0	103		
4/14/80	4:15	medium		1010	6.30	0	26		
4/21/80	1:12	very slow	16	1500	6.90	0	113		
4/28/80	1:05	slow	12	1510	8.3	0	138	780	
5/5/80	1:50	very slow	19	1550	7.73	0	156		
5/12/80		not collected							
5/19/80	3:30	slow	15	1310	7.58	0	95		- -
5/29/80	2:50	very slow	17.5	1520	7.18	0	165	700	- -
6/3/80	1:45	slow	15	sample did not arrive					
6/9/80	1:24	very slow	13	1420	7.45	2	121		- -
6/18/80	12:55	very slow	13.5	1580	7.98	0	172		- -
6/24/80	6:15	very slow	16	1650	7.64	0	140	680	- -
7/3/80	5:10	very slow	19	1700		0	175		- -
7/9/80	10:50 am	very slow	18	1570	7.51	0	147		- -

Bedway Site, Fairview, Ohio
Sample Location # 20 (cont.)

Date & Time of Collection		Q	Temp. °C	S. Cond. umho/cm	pH	Acidity mg/l as $CaCO_3$	Alkalinity mg/l as $CaCO_3$	Sulfate mg/l	Tracer $Br^-F^-I^-$
7/15/80	3:00	very slow	21	1680	7.94	0	147		- -
7/25/80	8:20	very slow	18	sample missing					
8/8/80	11:05 am	very slow	18	1510	8.31	0	105	600	- -
8/14/80	9:00	slow		1400	8.6	0	95		- -
8/22/80	12:50	very slow		1300	8.4	0	95		- -
8/28/80	3:47	very slow	22	1490	7.94	0	130		- - -
9/7/80	9:15	very slow	18		8.07	0	130	680	- -
9/16/80	4:25	very slow		1620	7.73	0	140		- - -
9/22/80	1:00	very slow	21	1600	7.94	0	156		- - -
10/1/80		dry							
10/6/80	2:10	very slow	12	1620	7.78	0	165		- - -
10/15/80		dry							
10/20/80	1:05	very slow	9	1490	7.74	0	197		- - -
10/27/80	1:40	very slow	8	1370	7.92	0	197	740	- - -
11/3/80	2:10	very very slow	9.5	1450	7.94	0	156		- - T
11/10/80		dry							
11/19/80		dry							
11/24/80		dry							
12/1/80	2:15	very very slow	8	1380	7.50	0	142	770	- - -
12/8/80		dry							
12/22/80		frozen							
12/29/80		dry							
1/6/81		frozen							
1/19/81		frozen							
1/26/81	1:30	very slow		1150	7.90	0	106	630	- - T
2/13/81		frozen							
2/17/81	4:08	slow	4.0	1050	7.15	0	70.8		- - -
2/25/81	5:00	very slow	5.0	1100	7.35	0	92.4	650	- - -
3/4/81	1:03	slow		1330	7.25	0	135.6		- - -

Bedway Site, Fairview, Ohio
Sample Location # 20 (cont.)

Date & Time of Collection	Q	Temp. ^oC	S. Cond. umho/cm	pH	Acidity mg/l as $CaCO_3$	Alkalinity mg/l as $CaCO_3$	Sulfate mg/l	Tracer $Br^-F^-I^-$
3/11/81 1:20	very slow	6.0	1320	7.58	0	128.4		- T
3/16/81	very slow		1400	7.20	0	139.6		- T
3/23/81	very slow	10.0	1470		0		760	- T
4/3/81 5:11	very slow	13.0	1440	7.45	0	173.2		- -
4/19/81 12:14	med. slow	8.0	1110	7.60	0	114.0		- -
4/25/81 11:52	very slow	9.0	1220	7.45	2	135.2	670	- -
5/1/81 6:58	very slow	9.0	1270	8.00	0	131		- -
5/9/81 8:02	very slow		1340	7.80	0	162		- -
5/15/81 11:50	very slow		1200	7.20	0	91		- T
5/24/81 12:32	very slow		1480	7.73	0	160		- T
5/31/81 1:08	very slow	16.0	1300	7.96	0	131		- T
6/7/81 12:35	very slow	15.0	1300	7.63	0	109		- T
6/16/81 11:24	very slow	17	1190	7.82	0	112		- -
6/26/81	dry							

Bedway Site, Fairview, Ohio
Sample Location # 21

Date & Time of Collection	Q	Temp. oC	S. Cond. umho/cm	pH	Acidity mg/l as $CaCO_3$	Alkalinity mg/l as $CaCO_3$	Sulfate mg/l	Tracer $Br^-F^-I^-$
6/19/79	low		4900	2.1	2780			
10/21/79	low		4000	3.08	2478	0		- -
12/3/79	very slow	7	2380	6.6	2.5	396		
12/10/79	dry							
12/17/79	frozen-no flow							
12/24/79 11:24	very slow	12	1900	6.5	0	392	1300	- -
1/2/80 11:07	very slow	7	1820	6.1	2	395		
1/8/80	frozen							
1/14/80 11:22	slow	10	2390	6.25		340		
1/22/80 4:05	very slow	7.0		6.69	3	375		
2/1/80	frozen							
2/4/80	frozen							
2/11/80	frozen							
2/19/80 3:54	very slow	8.0	2500	6.31	11	388		- -
2/25/80	no flow							
3/3/80	dry							
3/10/80 11:37	no flow							
3/17/80 12:05	very slow	11.0	3120	2.81	1015	0		
3/23/80	no flow							
3/31/80 11:50	very slow	18.0	4100	2.48	1817	0	2875	- -
4/7/80 1:28	very slow	17.0	4600	3.68	2206	0		
4/14/80	wrong sample collected							
4/21/80 2:20	very slow	23.0	4920	2.55	2249	0		
4/28/80 2:18	very slow	18.0	4710	2.41	2354	0	3775	- -
5/5/80 2:40	very slow	26.0	5150	2.29	2631	0		
5/7/80			4410	2.68	2604	0		
5/12/80	not collected							
5/19/80 4:40	very slow	20.5	4040	2.58	2042	0		- -
5/29/80	dry							
6/3/80 2:55	very slow	27.5	4220	2.32	2050	0		- -
6/9/80	no flow							

Bedway Site, Fairview, Ohio
Sample Location # 21 (cont.)

Date & Time of Collection	Q	Temp. oC	S. Cond. umho/cm	pH	Acidity mg/l as $CaCO_3$	Alkalinity mg/l as $CaCO_3$	Sulfate mg/l	Tracer $Br^-F^-I^-$
6/18/80	dry							
6/24/80	dry							
7/3/80	dry							
7/9/80	dry							
7/15/80	dry							
7/25/80	dry							
8/8/80	dry							
8/14/80	dry							
8/22/80 1:40	very slow		4210	2.65	1948	0		
8/28/80	dry							
9/7/80	dry							
9/16/80 5:10	very slow		2980	2.66	1944	0		- T
9/22/80	dry							
10/1/80	dry							
10/6/80	dry							
10/15/80	dry							
10/20/80	dry							
10/27/80 2:15		13.0	3580	2.73	1625	0		- T
11/3/80	dry							
11/10/80	dry							
11/19/80	dry							
11/24/80	dry							
12/1/80	dry							
12/8/80	dry							
12/22/80	dry							
12/29/80	dry							
1/6/81	frozen							
1/19/81	frozen							
1/26/81	dry							
2/13/81	dry							

Bedway Site, Fairview, Ohio
Sample Location # 21 (cont.)

Date & Time of Collection	Q	Temp. °C	S. Cond. umho/cm	pH	Acidity mg/l as $CaCO_3$	Alkalinity mg/l as $CaCO_3$	Sulfate mg/l	Tracer $Br^-F^-I^-$
2/17/81	dry							
2/25/81	dry							
3/4/81	dry							
3/11/81	dry							
3/16/81	dry							
3/23/81	dry							
4/3/81	dry							
4/19/81 11:50	very slow	13.5	4040	2.45				- -
4/25/81	dry							
5/1/81	dry							
5/9/81	dry							
5/15/81	dry							
5/24/81	dry							
5/31/81	dry							
6/7/81	dry							
6/16/81	dry							
6/26/81	dry							

Bedway Site, Fairview, Ohio
Sample Location # 22

Date & Time of Collection		Q	Temp. ^{0}C	S. Cond. umho/cm	pH	Acidity mg/l as $CaCO_3$	Alkalinity mg/l as $CaCO_3$	Sulfate mg/l	Tracer $Br^{-}F^{-}I^{-}$
4/3/79	3 pm	trickle	10.6	2250	3.6				
6/11/79	4:10 pm	low		2700	3.2	182	0		- -
6/16/79	11:30 am	very low	24.5	3190	3.15	126	0		
6/22/79	12:40 pm		21	3100	3.35	115	0		
6/29/79	2:07 pm	low	21	3150	3.25	139	0	2050	
7/7/79		dry							
7/14/79		dry							
7/23/79		dry							
7/30/79		dry							
8/6/79		dry							
8/13/79	12:55	very slow	22.5	2730	3.10	102	0		- -
8/22/79	1:45	very slow	15	2500	3.48	103	0		
8/28/79	1:45	medium	29.5	2600	3.16	93	0	1500	
9/4/79	1:37	very slow	22.5	2880	3.00	128	0		
9/10/79	1:45	slow	23	2880	3.25	119	0		
9/17/79	3:00	barely	22.5	2750	3.30	92	0		
9/24/79	1:10	very slow	19	2680	3.16	104	0	2050	
10/1/79	1:13	very slow	21	2460	3.10	44.6	0		- -
10/9/79	10:46 am	slow	14	2490	3.25	106	0		- -
10/15/79	12:19	slow	12.5	2650	3.08	126	0		- -
10/23/79	10:40	slow	14	2710	3.21	102	0		- -
10/29/79	12:20	very slow	12.5	2440	3.30	143	0	2060	- -
11/5/79	12:19	slow	9	2720	3.40	101	0		
11/12/79	12:05	very slow	7	2550	3.40	153	0		- T
11/18/79	1:50	very slow		2620	3.38	118	0		T T
11/26/79	11:45	slow	11	1980	3.44	49	0	1200	T T
12/3/79	12:31	slow	0	2500	3.40	330	0		
12/10/79	2:07	slow	4	2400	3.38	114	0		
12/17/79		frozen-no flow							
12/24/79	11:33	slow	9	1600	3.32	93	0	1500	

Bedway Site, Fairview, Ohio
Sample Location # 22 (cont.)

Date & Time of Collection		Q	Temp. ^{o}C	S. Cond. umho/cm	pH	Acidity mg/l as $CaCO_3$	Alkalinity mg/l as $CaCO_3$	Sulfate mg/l	Tracer $Br^-F^-I^-$
1/2/80	11:25	slow	1.5	2000	3.15	124	0		
1/8/80		frozen							
1/14/80		fast	1.0	2220	3.45	68	0		
1/22/80	4:00	medium	3.5		3.55	85	0		
2/1/80		frozen							
2/4/80		frozen							
2/11/80		frozen							
2/19/80	4:05	medium	0	1800	6.38	2	39		
2/25/80	11:00	very slow	0	2250	4.65	27	2	1320	
3/3/80		frozen							
3/10/80	10:49	med. slow	2.0	2420	4.39	51	0		
3/17/80	11:00	fast	10.0	1559	3.77	31	0		
3/23/80	12:50	fast	11.0	2400	3.65	46			
3/31/80	12:53	fast	12.0	2420	3.68	52	0	1400	
4/7/80	12:26	med. fast	10.0	2560	2.90	66	0		
4/14/80	4:42	med. slow		1400	4.37	25	0		
4/21/80	1:28	very slow	20.0	2630	3.71	96	0		
4/28/80	1:18	very slow	15.5	2580	3.70	62	0	1950	
5/5/80	2:03	very slow	19	2700	4.11	34	0		- -
5/12/80		sample not collected							
5/19/80	3:47	slow	21.5	2160	3.49	57	0		- -
5/29/80	3:08	very slow	24	2780	3.50	73	0	1730	- -
6/3/80	1:58	slow	23	2280	3.39	70	0		- -
6/9/80	1:38	very slow	12.5	2640	3.40	81	0		- -
6/18/80	1:03	very slow	25	2910	3.53	76	0		- -
6/24/80	7:34	very slow	22	3030	3.87	76	0	1690	- -
7/3/80		dry							
7/9/80	11:03	very slow	21.5	2900	3.41	64	0		- -
7/15/80		dry							
7/25/80	8:05	very slow	23	2880	3.49	70	0		- T

Bedway Site, Fairview, Ohio
Sample Location # 22 (cont.)

Date & Time of Collection		Q	Temp. °C	S. Cond. umho/cm	pH	Acidity mg/l as $CaCO_3$	Alkalinity mg/l as $CaCO_3$	Sulfate mg/l	Tracer $Br^-F^-I^-$
8/8/80	11:22	very slow	23	2780	3.70	41	0	1750	- -
8/14/80	9:22	slow		2610	6.52	1	13		- -
8/22/80	1:03	very slow		2420	4.90	21	1		- -
8/28/80	3:58	very slow	27	2770	3.70	34	0		- T
9/7/80	9:28	very slow	21	2800	3.80	34	0	1940	- -
9/16/80	4:21	very slow		2980	4.03	23	0		- -
9/22/80	1:30	very slow	22.5	2960	4.00	22	0		- -
10/1/80	1:25	very slow	18	3120	5.59	3	5	1870	- T
10/6/80	1:10	very slow	12	3060	5.49	4	5		- -
10/15/80	11:48	very slow	12	3060	4.95	15	3		- -
10/20/80	1:10	very slow	10.5	2720	6.01	2	12		- -
10/27/80				2180	5.00	12	3	1710	- T
11/3/80		dry							
11/10/80		dry							
11/19/80	2:43	slow	4	2030	4.38	28	0		- -
11/24/80	1:55	slow	6.5		4.97	12	2		- -
12/1/80	1:45	slow	6	1870	5.00	9	2	1230	- -
12/8/80	1:45	slow	10	1860	4.76	16	2		- -
12/22/80		frozen							
12/29/80		frozen							
1/6/81		frozen							
1/19/81		frozen							
1/26/81	12:59	slow	0.5	950	6.65	0	12.1	1100	- -
2/13/81		frozen							
2/17/81	4:10	slow	6.0	1650	4.08	34	0		- -
2/25/81	4:35	fast		1900	4.55	15.6	0	1425	- -
3/4/81	12:46	slow	5.0	2180	4.22	39.6	0		- -
3/11/81	12:55	slow		2170	4.30	36.8	0		- -
3/16/81	2:10	slow		2130	4.28	49.2	0		- -

Bedway Site, Fairview, Ohio
Sample Location # 22 (cont.)

Date & Time of Collection	Q	Temp. °C	S. Cond. umho/cm	pH	Acidity mg/l as $CaCO_3$	Alkalinity mg/l as $CaCO_3$	Sulfate mg/l	Tracer $Br^-F^-I^-$
3/23/81 2:26	very slow		2350	4.85	22.0	4.4	1730	- -
4/3/81	dry							
4/19/81 12:04	medium	12	2120	5.90	0	15.0		- -
4/25/81 11:43	slow	9.0	2130	4.95	23.6	2.0	1500	- -
5/1/81 6:39	slow	6.0	2230	5.20	14.8	4.8		- T
5/9/81 7:24	slow	5.5	2330	5.01	9.6	5.2		- -
5/15/81 11:31	very slow		1780	5.60	2.20	4.3		- T
5/24/81 12:23	very slow		2550	4.88	15.4	3.33		- T
5/31/81 12:54	very slow	21.0	2100	4.53	8.16	1.60		- T
6/7/81 12:28	slow	23.5	2250	7.01	0	26.6		- T
6/16/81 11:11	slow	21.0	2100	7.15	0	33.3		- T
6/26/81 6:53	fast	25.5	2120	7.60	0	65.9		- T

Bedway Site, Fairview, Ohio
Sample Location # 23

Date & Time of Collection		Q	Temp. °C	S. Cond. umho/cm	pH	Acidity mg/l as $CaCO_3$	Alkalinity mg/l as $CaCO_3$	Sulfate mg/l	Tracer $Br^-F^-I^-$
6/13/79		0.04 cfs	16.5	4310	2.69	1433	0		
6/16/79	1:30 pm	½ cfs	11.5	4250	2.68	1510	0		
6/22/79	6:00 pm		13	4150	2.75	1510	0		
6/29/79	5:25 pm	low	15	4090	2.81	1377	0	5950	
7/7/79	4:25 pm	low	17	3990	2.82	1311	0		
7/16/79	5:30 pm	low	19	3950	3.0	1336	0		
7/23/79	4:00 pm	medium	11	4210	2.75	1165	0		-
7/30/79	4:10 pm	slow	19	4060	2.65	1340	0	3100	
8/6/79	2:40 pm	medium		4250	2.60	1290	0		
8/13/79	3:20 pm	slow	11	3850	2.65	1250	0		-
8/22/79		(no sample collected)							
8/28/79	1:45 pm	medium	16	3900	2.75	1310	0	3075	-
9/4/79	2:50 pm	medium	15	3920	2.62	1350	0		
9/10/79	2:45 pm	medium	15	3790	2.76	1390	0		
9/17/79	3:25 pm	medium	15	3750	2.75	1300	0		
9/24/79	1:25 pm	medium	14	3620	2.75	1260	0	2940	
10/1/79	1:45 pm	medium	14.5	3500	2.88	1130	0		- -
10/9/79	11:15 am	medium	12	3500	2.72	1150	0		- -
10/15/79	1:15 pm	med. flow	13	3500	2.86	1190	0		- -
10/23/79	11:10 am	slow	13	2510	2.88	1190	0		- -
10/29/79	1:10 pm	med. flow	13	3220	2.98	1100	0	2700	- - -
11/5/79	1:10 pm	slow	10.5	3600	2.94	1110	0		
11/12/79	1:15 pm	med. slow	10.5	3600	3.08	1080	0		- -
11/18/79	3:30	medium	11	3620	2.85	981	0		- -
11/26/79	1:40	very slow	10.5	3520	2.90	972	0	2625	- -
12/3/79	1:25	slow	6	3480	3.02	1010	0		
12/10/79	1:45	slow	6	3480	2.92	1020	0		
12/17/79	2:15 pm	very slow	4	3200	2.80	1050	0		
12/24/79	1:20	slow	10	2490	2.78	906	0	2650	
1/2/80	12:30	very slow	6	2610	2.78	855	0		

Bedway Site, Fairview, Ohio
Sample Location # 23 (cont.)

Date & Time of Collection		Q	Temp. °C	S. Cond. umho/cm	pH	Acidity mg/l as $CaCO_3$	Alkalinity mg/l as $CaCO_3$	Sulfate mg/l	Tracer $Br^-F^-I^-$
1/8/80	3:50	very slow	5	2880	2.90	948	0		
1/14/80	12:35	very slow	8.0	3700	2.95	936	0		
1/22/80	4:40	very slow	5.0		3.09	900	0		
2/1/80	2:20	very slow	3.0	3490	3.21	1036	0		- -
2/4/80	11:00	very slow	2.5	3790	3.07		0		- -
2/11/80	10:55	very slow	3.0	3790	2.81	1088	0		
2/19/80	4:00	very slow	7.0	3630	2.90	944	0		
2/25/80	12:02 pm	very slow	6.0	3620	2.93	936	0	2700	
3/3/80		frozen							
3/17/80	11:05	very slow	7.0	3700	2.90				
3/23/80	1:35	slow	11.0	3800	2.85	1194			
3/31/80	1:40 pm	slow	11.0	4000	2.88	1422	0	2980	
4/7/80	1:10	very slow	11.0	3850	2.95	1290	0		
4/14/80	3:30	very slow		3220	2.88	978	0		
4/21/80	12:35	very slow	14	3820	2.85	1536	0		
4/28/80	12:35	very slow	12.5	3760	2.81	1202	0	3075	
5/5/80	1:03	very slow	16.5	3690	2.75	1329	0		- -
5/12/80	2:15	very slow	14	3590	2.78	1071	0		- -
5/19/80	2:45	very slow	14.5	3450	2.86	1110	0		- -
5/29/80	1:42	very slow	16.5	3690	2.79	1233	0	2700	- -
6/3/80	1:10	very slow	16	3430	2.72	1256	0		- -
6/9/80	12:40	very slow	13	3530	2.86	1224	0		- -
6/18/80	12:30	very slow	14	3770	2.98	1305	0		- -
6/24/80	6:35	very slow	16	4020	2.98	1118	0	2650	- -
7/3/80	4:45	very slow	22	4070	2.85	1151	0		- -
7/9/80	10:10	very slow	18	3910	2.64	1145	0		- -
7/15/80	2:40	very slow	24	4120	2.81	1246	0		- -
7/25/80		dry							
8/8/80	10:15	very slow	17	3790	2.89	1005	0	2230	- -
8/14/80	8:10	very slow		3800	2.82	1075	0		- -

Bedway Site, Fairview, Ohio
Sample Location # 23 (cont.)

Date & Time of Collection	Q	Temp. ^oC	S. Cond. umho/cm	pH	Acidity mg/l as $CaCO_3$	Alkalinity mg/l as $CaCO_3$	Sulfate mg/l	Tracer $Br^-F^-I^-$
8/22/80 12:10	slow		3610	2.87	998	0		- -
8/28/80 3:13	very slow	15	3670	2.81	976	0		- -
9/7/80 8:43	very slow	14		2.91	995	0	2350	- -
9/16/80 4:05	very slow		3600	2.92	929	0		- -
9/22/80 1:50	very slow	16	3560	2.83	936	0		- -
10/1/80 1:55	very slow	16	3600	2.80	865	0	2560	- -
10/6/80 1:40	very slow	11.5	3600	2.89	843	0		- -
10/15/80 12:20	very slow	12	3680	2.88	935	0		- -
10/20/80 1:35	very slow	10.5	3340	2.91	794	0		- -
10/27/80 2:10	very slow	10	3130	2.91	888	0	2480	- -
11/3/80 1:45	very slow	10	3330	2.88	872	0		- -
11/10/80 2:20	very slow	9	3500	2.80	880	0		- -
11/19/80 3:05	very slow	6	3360	2.87	931	0		- -
11/24/80 1:40	very slow	8	2070	2.80	860	0		- -
12/1/80 1:46	very slow	8	3350	2.83	856	0	2400	- -
12/8/80 1:35	very slow	10.5	3290	2.82	845	0		- T
12/22/80 2:25	very slow	2.0	3100	2.88	865	0		
12/29/80 1:25	very slow	5	3100	2.88	824	0	2550	- -
1/6/81	frozen							
1/19/81	frozen							
1/26/81 1:00	very slow		3500	2.80	1025	0	2540	- -
2/13/81 1:35	very slow		3000	2.85	1120	0		- -
2/17/81 3:00	very slow		2900	2.83	855	0		- -
2/25/81 4:32	very slow	7.0	3050	2.80	925	0	2620	- -
3/4/81 3:50	very slow	7.0	3350	2.80	1060	0		- -
3/11/81 1:15	very slow	7.0	3340	2.80	960	0		- -
3/16/81 2:15	very slow	8.0	3390	2.80	960	0		- -
3/23/81	no flow-dry							
4/3/81	dry							
4/19/81 11:40	slow	11.0	3270	2.70	1070	0		- -

Bedway Site, Fairview, Ohio
Sample Location # 23 (cont.)

Date & Time of Collection	Q	Temp. ^{o}C	S. Cond. umho/cm	pH	Acidity mg/l as $CaCO_3$	Alkalinity mg/l as $CaCO_3$	Sulfate mg/l	Tracer $Br^-F^-I^-$
4/25/81 12:44	very slow	8.5	3170	2.63	1070	0	2325	- -
5/1/81	dry							
5/9/81	dry							
5/15/81	dry							
5/24/81	dry							
5/31/81	dry							
6/7/81	very slow	12.0	3180	2.93	912	0		- -
6/16/81 10:39	very slow	14.0	2920	2.92	875	0		- -
6/26/81 6:35	very slow	15.0	2800	3.15	806	0		- -

Bedway Site, Fairview, Ohio
Sample Location # 24

Date & Time of Collection	Q	Temp. ^{o}C	S. Cond. umho/cm	pH	Acidity mg/l as $CaCO_3$	Alkalinity mg/l as $CaCO_3$	Sulfate mg/l	Tracer $Br^-F^-I^-$
6/13/79	low	14.5	5380	2.58	1854	0		
6/16/79 1:45	low	14.5	5390	2.58	1962	0		
6/22/79 3:26		14	5320	2.65	1120	0		
6/29/79 5:03	low	15	5390	2.65			4450	
7/7/79 4:30	very low	16	5280	2.65	2060	0		
7/14/79 5:15			5200	2.86	2250	0		
7/23/79 3:45	very little	14	5530	2.62	1950	0		
7/30/79	dry							
8/6/79	dry							
8/13/79 2:55	very slow	16	4690	2.52	1580	0		
8/22/79	(no sample collected)							
8/28/79 3:00	medium	15	4520	2.78	1320	0	3580	
9/4/79 2:40	slow	16	4770	2.60	1730	0		
9/10/79 2:35	very slow	16	4880	2.65	1850	0		
9/17/79 3:25	slow	16	4960	2.75	1960	0		
9/24/79 1:00	slow	15	4810	2.66	1920	0	4225	
10/1/79 1:20	medium	15	4680	2.78	1690	0		T
10/9/79 10:48	medium	13	4500	2.70	1520	0		T
10/15/79 1:00	slow	13	4580	2.76	1850	0		-
10/23/79 10:55 am	slow	13.5	4620	2.78	1750	0		- - -
10/29/79 12:55	very slow	12.5	4220	2.90	1640	0	4300	T
11/5/79 12:58	very slow	10	4740	2.88	1650	0		-
11/12/79 12:40	very slow	10	4750	3.05	1760	0		- - -
11/18/79	dry							
11/26/79 1:25	very slow	10	4730	2.84	2020	0	3890	- -
12/3/79	dry							
12/10/79	dry							
12/17/79	dry							
12/24/79 11:45	medium	10	3260	2.70	1648	0	2015	- -
1/2/80	dry							

Bedway Site, Fairview, Ohio
Sample Location # 24 (cont.)

Date & Time of Collection		Q	Temp. oC	S. Cond. umho/cm	pH	Acidity mg/l as $CaCO_3$	Alkalinity mg/l as $CaCO_3$	Sulfate mg/l	Tracer $Br^-F^-I^-$
1/8/80		frozen-no flow							
1/14/80	12:12	med. slow	10	4510	2.85	1074	0		
1/22/80		dry							
2/1/80		frozen							
2/4/80		frozen							
2/11/80		frozen							
2/19/80		dry							
2/25/80		dry							
3/3/80		frozen							
3/10/80		dry							
3/17/80		dry							
3/23/80		dry							
3/31/80		dry							
4/7/80		dry							
4/14/80		slow		3750	2.89	1022	0		
4/21/80	12:50	med. slow	13	4410	2.80	1020	0		
4/28/80	12:45	slow	12.0	4590	2.70	1538	0	3800	
5/5/80	1:24	very slow	14	4610	2.64	1715	0		- - -
5/12/80		no sample collected							
5/19/80	3:00	slow	12.5	4280	2.80	1383	0		- - -
5/29/80	2:30	very slow	14	4590	2.69	1620	0	3450	- - -
6/3/80	1:20	slow	14	3990	2.70	1284	0		- - -
6/9/80	12:55	very slow	12.5	4390	2.77	1609	0		- - -
6/18/80	12:35	very slow	13	4180	2.90	1690	0		- - -
6/24/80		dry							
7/3/80		dry							
7/9/80		dry							
7/15/80		dry							
7/25/80		dry							
8/8/80		dry							

Bedway Site, Fairview, Ohio
Sample Location # 24 (cont.)

Date & Time of Collection		Q	Temp. ^oC	S. Cond. umho/cm	pH	Acidity mg/l as $CaCO_3$	Alkalinity mg/l as $CaCO_3$	Sulfate mg/l	Tracer $Br^-F^-I^-$
8/14/80		dry							
8/22/80	12:25	very slow		4330	2.89	1281	0	3050	- - -
8/28/80		dry							
9/7/80		dry							
9/16/80		dry							
9/22/80		dry							
10/1/80		dry							
10/6/80		dry							
10/15/80		dry							
10/20/80		dry							
10/27/80		dry							
11/3/80		dry							
11/10/80		dry							
11/19/80		dry							
11/24/80		dry							
12/1/80		dry							
12/8/80		dry							
12/22/80		frozen							
12/29/80		dry							
1/6/81		frozen							
1/19/81		frozen							
1/26/81		dry							
2/13/81		frozen							
2/17/81	3:20	very slow	8.0	3380	2.83	1030	0		- - -
2/25/81		sample not collected							
3/4/81	4:03	very slow	9.0	3890	2.80	1535	0		T
3/11/81	1:30	very slow	8.0	3850	2.80		0		-
3/16/81	2:35	very slow	8.0	4190	2.79	1685	0		T
3/23/81	2:25	very slow	9.5	4160	2.75	1355	0	3360	-
4/3/81		dry							

Bedway Site, Fairview, Ohio
Sample Location # 24 (cont.)

Date & Time of Collection		Q	Temp. °C	S. Cond. umho/cm	pH	Acidity mg/l as $CaCO_3$	Alkalinity mg/l as $CaCO_3$	Sulfate mg/l	Tracer $Br^-F^-I^-$
4/19/81	11:50	medium	11.0	3700	2.76	1395	0		–
4/25/81	12:58	med. slow	10.0	3800	2.69	1335	0	3080	T
5/1/81		dry							
5/9/81		dry							
5/15/81	11:17	dry							
5/24/81		dry							
5/31/81		very slow	13.0	3850	2.90	1275	0		–
6/7/81	1:08	med. slow	12.0	3850	3.10	1050	0		–
6/16/81	10:50	slow	14.0	3400	3.05	1016	0		–
6/26/81	6:55	med. slow	13.0	3280	3.15	702	0		T

Bedway Site, Fairview, Ohio
Sample Location # 25

Date & Time of Collection	Q	Temp. °C	S. Cond. umho/cm	pH	Acidity mg/l as $CaCO_3$	Alkalinity mg/l as $CaCO_3$	Sulfate mg/l	Tracer $Br^-F^-I^-$
6/13/79	very low	15	3400	3.01	380	0		
6/16/79		16	3400	3.01	410	0		
6/29/79 5:45	low	11	3650	2.96	387	0	2025	
7/7/79	(no sample collected)							
7/14/79		13	3150	3.10	375	0		
7/23/79 1:30	medium	19	3350	2.95	318	0		
7/30/79 12:45	slow	19	3310	2.72		0	2125	-
8/6/79 12:30	slow	20	3320	2.82	330	0		
8/13/79 12:30	slow	15	3110	2.80	325	0		
8/22/79 1:20	slow	18	3060	2192	320	0		
8/28/79 1:25	slow	20	3080	2.88	815	0	1875	
9/4/79 1:20	slow	20.5	2850	2.98	367	0		
9/10/79 1:30	slow	19.5	2980	3.02	385	0		
9/17/79 2:45	very slow	19	3020	3.10	399	0		
9/24/79 1:40	slow	19	2980	2.98	993	0	2050	
10/1/79 1:55	very slow	18.5	2820	3.10	305	0		
10/9/79 11:28	slow	16	2800	3.00	301	0		-
10/15/79 1:25	slow	17	2840	3.1	316	0		-
10/23/79 11:18	slow	16.5	2800	3.15	291	0		-
10/29/79 1:20	slow	15	2590	3.28	306	0	1950	- -
11/5/79 1:20	very slow	13.5	2980	3.12	301	0		- -
11/12/79 1:25	slow	13	3000	3.45	338	0		T T
11/18/79 3:50	very slow	13	3020	3.00	250	0		- -
11/26/79 1:55	slow	12.5	2980	3.22	306	0	1950	- -
12/3/79 1:40	very slow	11	2860	3.35	285	0		
12/10/79 2:05	slow	9.5	2800	3.20	295	0		
12/17/79 2:30	very slow	8.5	2580	3.08	299	0		
12/24/79 1:30	very slow	10	2120	2.95	257	0	2015	
1/2/80 12:45	very slow	8	2150	3.00	257	0		
1/8/80 4:15	very slow	8	2390	3.15	299	0		

Bedway Site, Fairview, Ohio
Sample Location # 25 (cont.)

Date & Time of Collection		Q	Temp. °C	S. Cond. umho/cm	pH	Acidity mg/l as $CaCO_3$	Alkalinity mg/l as $CaCO_3$	Sulfate mg/l	Tracer $Br^-F^-I^-$
1/14/80	12:50	very slow	9	3020	3.19	278	0		
1/22/80	5:25	very slow	7.0		3.40	239	0		
2/1/80	3:10	very slow	5.0	2900	3.49	303	0		- T
2/4/80	11:35	very slow	5.0	2980	3.43	282	0		- T
2/11/80	11:40	very slow	6.0	3030	3.10	308	0		
2/19/80	4:30	very slow	8.0	2990	3.18	285	0		
2/25/80	12:25	very slow	7.0	2880	3.35	277	0	1800	
3/3/80		frozen							
3/10/80	11:35	very slow	2.0	3060	3.10	318	0		
3/17/80	11:45	very slow	7.0	3000	3.18	277	0		
3/23/80	2:10	very slow	7.5	2750	3.05	306	0		
3/31/80	2:05	very slow	8.0	2970	3.01	391	0	1600	
4/7/80	1:35	very slow	8.0	2990	3.00	320	0		
4/14/80	3:14	very slow	8.0	2940	3.02	506	0		
4/21/80	12:20	very slow	10	3000	3.02	328	0		
4/28/80	12:20	very slow	10	2990	3.01	412	0	1875	
5/5/80	12:50	very slow	11.0	2930	2.89	456	0		- -
5/12/80	1:50	very slow	11.0	3040	2.87	330	0		- -
5/19/80	2:30	slow	12.0	2880	3.03	306	0		- -
5/29/80	1:25	very slow	14	2910	2.89	328	0	1780	- -
6/3/80	12:55	slow	14	2790	2.90	313	0		- -
6/9/80	12:55	slow	14	2800	3.02	317	0		- -
6/18/80	12:17	very slow	15	3000	3.07	299	0		- -
6/24/80	6:45	slow	16	3200	3.08	252	0	1730	- -
7/3/80	4:20	very slow	18	3190	3.08	266	0		- T -
7/9/80	9:50	very slow	17	3190	2.80	262	0		- -
7/15/80	2:08	very slow	19	3300	3.00	235	0		- -
7/25/80	7:20	very slow	19	3290	2.92	235	0		- -
8/8/80	9:50 am	slow	18	3130	3.03	281	0	1850	- -
8/14/80	7:50	very slow		3090	2.90	351	0		- -

Bedway Site, Fairview, Ohio
Sample Location # 25 (cont.)

Date & Time of Collection	Q	Temp. °C	S. Cond. umho/cm	pH	Acidity mg/l as $CaCO_3$	Alkalinity mg/l as $CaCO_3$	Sulfate mg/l	Tracer $Br^-F^-I^-$
8/22/80 11:50	very slow		3230	3.00	412	0		- -
8/28/80 3:00	very slow	20	3400	2.89	378	0		- -
9/7/80 8:25	very slow	18		3.02	380	0	2200	- -
9/22/80 2:10	very slow	18.5	3140	3.06	342	0		- -
10/1/80 1:25	very slow	20	3060	3.06	293	0	1910	- T
10/6/80 1:20	very slow	17	3040	3.20	294	0		- -
10/15/80 11:50	very slow	11.5	3080	3.08	243	0		- T
10/20/80 1:55	very slow	15.5	2700	3.40	241	0		- -
10/27/80 2:53	very slow	15	2520	3.38	248	0	2000	- -
11/3/80 1:15	very slow	14	2680	3.26	236	0		- T
11/10/80 1:55	very slow	13.2	2710	3.29	248	0		- -
11/19/80 2:25	very slow	11	2720	3.20	229	0		- -
11/24/80 1:05	very slow	12		3.02	200	0		- -
12/1/80 1:15	very slow	11	2740	3.11	170	0	1875	- -
12/8/80 1:00	very slow	12	2610	3.23	211	0		- -
12/22/80	frozen							
12/29/80 12:52	very slow	9	2430	3.26	194	0	1990	- -
1/6/81 5:10	very slow	8	2070	3.40	189	0		- -
1/19/81 1:00	very slow	7.0	2690	3.19	242	0		- -
1/26/81 12:45	very slow		2760	3.20	211	0	1850	- -
2/13/81 1:00	very slow		2500	3.00	307	0		- -
2/17/81 3:35	very slow	7.0	2550	3.00	193	0		- -
2/25/81 4:15	very slow	6.0	2450	2.89	197	0	1675	- -
3/4/81 3:35	very slow	6.5	2550	3.0	220	0		- -
3/11/81 12:45	very slow	6.5	2558	3.02	204	0		- -
3/16/81 1:58	very slow	7.0	2750	3.01	139	0		- -
3/23/81 1:55	very slow	7.0	2770	2.95	128	0	1925	- -
4/3/81 4:20	very slow	9.0	2600	3.05	435	0		- -
4/19/81 11:24	very slow	9.0	2350	2.97	736	0		- -
4/25/81 12:25	very slow	9.0	2670	2.87	385	0	1825	- -

Bedway Site, Fairview, Ohio
Sample Location # 25 (cont.)

Date & Time of Collection	Q	Temp. ^{o}C	S. Cond. umho/cm	pH	Acidity mg/l as $CaCO_3$	Alkalinity mg/l as $CaCO_3$	Sulfate mg/l	Tracer $Br^-F^-I^-$
5/1/81	very slow	9.0	2800	3.19	328	0		- -
5/9/81 7:25	very slow		2810	3.14	356	0		- -
5/15/81 10:55			2800	3.10	357	0		- -
5/24/81 12:20	very slow	12.0	2850	3.00	318	0		- -
5/31/81 11:55	very slow	14.0	2600	3.12	265	0		-
6/7/81 11:20	very slow	15.0	2700	3.15	287	0		- -
6/16/81 10:20	very slow	16.5	2410	3.13	266	0		- -
6/26/81 6:18	very slow	16.5	2470	3.30	281	0		- -

Bedway Site, Fairview, Ohio
Sample Location # C

Date & Time of Collection	Q	Temp. °C	S. Cond. umho/cm	pH	Acidity mg/l as $CaCO_3$	Alkalinity mg/l as $CaCO_3$	Sulfate mg/l	Tracer $Br^-F^-I^-$
4/3/79 11:00		10.1	700	5.7	7.8		608	
6/11/79 2:45			551	4.21	23.5	0		
6/16/79 10:30	very low	20	3170	3.10	267	0		
6/22/79 11:45		17	3410	3.10	231	0		
6/29/79 3:00		18	3400	3.12	274	0	2280	
7/7/79 5:00	low	18	3270	3.20	163	0		
7/14/79 5:50	low	20	3210	3.05	279	0		
7/23/79 2:00			3580	2.99	283	0		
7/30/79 2:05	slow	19	1680	3.80	58	0	1010	- -
8/6/79 1:15	very slow	23	3410	2.90	247	0		
8/13/79 1:25	slow	22	550	5.90	0			-
8/22/79 2:00	very slow	17.5	2700	2.98	229	9		
8/28/79 2:05	medium	31	382	6.24	0		150	- -
9/4/79 1:50	very slow	22	2610	3.06	85	0		
9/10/79 1:58	very slow	19	2800	3.32	208	0		
9/17/79 3:35	slow	17	2860	3.10	195	0		
9/24/79 1:57	medium	19.5	1190	4.59	18	0	740	- -
10/1/79 2:08	medium	22	612	6.30	16.1			- -
10/9/79 11:40	medium fast	14	582	6.25		70.4		- -
10/15/79 1:01	slow	11	1700	4.22	69	0		- -
10/23/79 11:31 am	slow	12	2800	3.20	182	0		- -
10/29/79 1:10	very slow	12	2670	3.26	210	0	2155	- -
11/5/79 12:57	slow	9	2980	3.15	211	0		
11/12/79 12:34	slow	5.5	1740	4.46	73	0		- -
11/18/79 2:15	very slow	10.5	2330	4.16	74	0		- T
11/26/79 12:47	med. fast	12	560	6.45	0		170	- T
12/3/79 1:35	slow	2	1900	4.2	69	0		
12/10/79 1:30	slow	6.5	2580	3.30	160	0		
12/17/79 1:17	slow	2.0	2550	3.24	172	0		
12/24/79 12:08	med. fast	10	1580	5.90	0	63	4250	

Bedway Site, Fairview, Ohio
Sample Location # C (cont.)

Date & Time of Collection	Q	Temp. oC	S. Cond. umho/cm	pH	Acidity mg/l as $CaCO_3$	Alkalinity mg/l as $CaCO_3$	Sulfate mg/l	Tracer $Br^-F^-I^-$
1/2/80 11:47	slow	3.5	2000	3.2	103	0		
1/8/80 4:13	slow	1.5	2020	3.40	124	0		
1/14/80 12:14	fast	3.0	722	5.90	2	22		
1/22/80 4:40	medium	3.0		4.53	50	4	1070	
2/1/80 2:40	slow	2.0	3000	3.91	146	0		- -
2/4/80	frozen							
2/11/80	frozen							
2/19/80 3:26	very slow	2.0	2420	3.51	111	0		
2/25/80 11:45 am	fast	2.5	469	6.69	0	62		
3/3/80	frozen							
3/10/80 11:30	good	10.0	352	6.60	7	31		
3/17/80 12:03	fast	9.0	405	6.51	5	25		
3/23/80 1:24	fast	14.0	570	6.40	0	46		
3/31/80 1:39	fast	15.0	850	6.60	0	47	300	
4/7/80 1:16	medium	13.0	1200	6.12	0	63		
4/14/80 5:35	fast		1100	6.30	0	69		
4/21/80 2:10	slow	15.5	2350	4.60	162	6		
4/28/80 1:58	slow	18.0	1800	6.90	2	51	1480	
5/5/80			2990	4.05	95	0		- -
5/12/80	not collected							
5/19/80 4:29	fast	22	1020	6.94	0	51		- -
5/29/80 3:45	very slow	27	2800	6.75	0	89	1830	- -
6/3/80 2:45	fast	18	1000	6.63	0	50		- -
6/9/80 2:14	slow	20	1240	7.40	4.3	61		- -
6/18/80 1:30	very slow	26	1700	6.63	0	4.5		- -
6/24/80 8:25	very slow	21.3	3160	3.93	74.5	0	2200	- -
7/3/80			3300	3.75	137.4	0		- -
7/9/80 11:45	medium	21	749	6.83	0	58		- -
7/15/80 3:50	very slow	22	3130	4.17	109	0		- -
7/25/80			1510	7.47	5.1	26.3		- -

Bedway Site, Fairview, Ohio
Sample Location # C (cont.)

Date & Time of Collection		Q	Temp. °C	S. Cond. umho/cm	pH	Acidity mg/l as $CaCO_3$	Alkalinity mg/l as $CaCO_3$	Sulfate mg/l	Tracer $Br^-F^-I^-$
8/8/80	11:55	medium	26	1140	8.14	0	61	450	- -
8/14/80		not collected							
8/22/80	1:28	fast		1120	7.32	4.0	62		- -
8/28/80	4:40	fast	23	2280	5.41	8	6		- - -
9/7/80					4.69	50	3	1540	- - -
9/16/80	4:57	med. slow		3320	3.57	126	0		- -
9/22/80	2:00	slow	20.5	3280	3.30	125	0		- T
10/1/80	2:05	very slow	18.5	3380	3.27	132	0	2270	- -
10/6/80	1:43	slow	12	3360	3.33	133	0		- - -
10/15/80	12:17	slow	13	3400	3.33	131	0		- - -
10/20/80	1:45	very slow	11	3080	3.39	113	0		- - -
10/27/80	2:35	very slow	10	2740	3.49	111	0	2180	- - T
11/3/80	1:35	slow	10.5	2890	3.34	134	0		- - -
11/10/80	12:05	very slow	8.5	3030	3.28	139	0		- - -
11/19/80	2:00	slow	5	2930	3.30	109	0		- - -
11/24/80	1:00	slow	8		3.32	95	0		- - -
12/1/80	1:00	med. slow	8.5	2290	3.30	79	0	1570	- - -
12/8/80	1:00	slow	10.5	2200	3.24	106	0		- - -
12/22/80	1:45	very slow	0	2140	3.17	131	0		- - T
12/29/80	12:30	very slow	5	2120	3.39	102	0	1500	- - -
1/6/81		frozen							
1/19/81	12:43	very slow	-1.0	2650	5.15	67	0		- - -
1/26/81	12:15	med. slow			3.40	42	0	560	- - -
2/13/81		frozen							
2/17/81	3:40	fast	1.5	2550	6.12				- - T
2/25/81	4:00	fast		41.5	6.40	0	2		- - -
3/4/81	12:00	med. slow	7.0	1340	3.89	82	0		- - T
3/16/81	1:25	med. slow		1650	4.60	37	0		- - T
3/23/81	1:43	slow	7.0	2670	3.18	136	0	1800	- - -
4/3/81	4:15	slow	10.0	2920	3.08	170	0		- - -

Bedway Site, Fairview, Ohio
Sample Location # C (cont.)

Date & Time of Collection		Q	Temp. °C	S. Cond. umho/cm	pH	Acidity mg/l as $CaCO_3$	Alkalinity mg/l as $CaCO_3$	Sulfate mg/l	Tracer Br^- F^- I^-
4/19/81	11:15	very fast	12.0	1440	6.0	6	59.0		- - -
4/25/81	11:10	fast	9.0	1220	6.50	32	28.8	720	- - -
5/1/81		medium	8.0	1650	6.20	3			- -
5/9/81	7:00	medium	4.0	2540	4.02	98	0		- - -
5/15/81	12:35	very fast		1190	7.0	3.3	147		- - -
5/24/81	11:55	medium		2720	3.32	113	0		- - -
5/31/81	12:25	med. slow	23.5	1200	7.65	0	89.2		- - T
6/7/81	11:55	med. fast	25.0	419	7.30	0	63.8		- - T
6/16/81	12:04	medium	25.0	1600	6.80	5.2	40.0		- - T
6/26/81	6:05	fast	25.0	1200	6.13	2.6	36.2		T - T

Bedway Site, Fairview, Ohio
Rainfall

Date & Time of Collection	inches	S. Cond. umho/cm	pH	Acidity mg/l as $CaCO_3$	Alkalinity mg/l as $CaCO_3$	Sulfate mg/l	Tracer $Br^-F^-I^-$
4/2 - 4/5/79	0.27	48	3.98		0		
6/11/79 12 pm	0.75	72	3.65	28.6	0		
6/22/79	0						
6/29/79	2121	121		13	0		
7/7/79	1.55	80	3.90	20.4	0		
7/23/79	0.31	98	3.72	15.0			
7/30/79	2.47	49	3.70	10.8	0		
8/6/79	0.11		4.80	9.6			
8/13/79	3.15	40.5	3.80	4.6	0	<9	- -
8/22/79	1.20	54.5	3.68	12.3	0		
8/28/79	2.58	45.2	3.58	13.8	0	<9	
9/4/79	1.10	56.8	3.54	26.9	0		
9/10/79	0						
9/17/79	rain gage stolen						
9/24/79	0.50						
10/1/79	0						
10/9/79	0.90	73.8	5.400	1.4			
10/15/79	0.42	41.5	5.20	1.9			
10/23/79	0.50						
10/29/79	0.50		4.18	6.4	0	<9	
11/5/79	0.44		5.78	4.6			
11/12/79	0.94	58.8	3.68	9.7	0	<9	- -
11/18/79	0.10						
11/26/79	1.10	32.5	3.56	10.8	0		
12/3/79	(frozen rain & snow) ≈0.10						
12/10/79	0.26						
12/17/79	frozen- no data						
12/24/79	0.92	33.5	3.70	4.0	0		

Bedway Site, Fairview, Ohio
Rainfall (cont.)

Date & Time of Collection	inches	S. Cond. umho/cm	pH	Acidity mg/l as $CaCO_3$	Alkalinity mg/l as $CaCO_3$	Sulfate mg/l	Tracer Br^-	F^- I^-
1/2/80								
1/8/80	3" of snow							
1/14/80	no spl.							
1/22/80	no spl.							
2/1/80	no spl.							
2/4/80	not enough snow to collect							
2/11/80								
2/19/80	snow	90	3.90	12.4				
2/25/80		128	5.08	4.4	7			
3/3/80	snow	315	6.65	2				
3/10/80		89	3.70	10.8	0			
3/17/80		54	3.98	11.6	0			
3/23/80		45	5.20	4.5	0			
3/31/80		56.5	3.92	5.5	0			
4/7/80	0							
4/14/80	0							
4/21/80		64	4.51	11	1			
4/28/80		53.9	4.78	4.4	0.8			
5/5/80	0	96	5.39					
5/12/80	0.4"			3.5	6.0		-	T
5/19/80	2.35"	30	5.30	0	2.6		-	T
5/29/80	0.52			0				
6/3/80			5.91	0	4.7		-	-
6/9/80		85	4.09	10.3	0		-	-
6/18/80	1.30"	47.9	5.15	4.4	3.2		-	-
6/24/80	0.05	*	*	*	*			
7/3/80	0.05	*	*	*	*			

* insufficient volume of sample

Bedway Site, Fairview, Ohio
Rainfall (cont.)

Date & Time of Collection	inches	S. Cond. umho/cm	pH	Acidity mg/l as $CaCO_3$	Alkalinity mg/l as $CaCO_3$	Sulfate mg/l	Tracer $Br^-F^-I^-$
7/9/80	1.45	51	4.48	4.7	0		- T
7/15/80	0.94"	42.3	5.04	3.3	1.7		- -
7/25/80	4.15"	36	4.46	4.4	0		- -
8/8/80	4.10"	47.8	4.37	5.0	0		- T
8/14/80	4.75"	56.2	4.32	6.0	0		- T
8/22/80	2.2"	50.4	4.40	6.0	0		- -
8/28/80	0						
9/7/80	0.90"		3.70	4.0	0		- - -
9/16/80	0.20	65.0	4.31	4.0	0		T T
9/22/80	0.03	*	*	*	*		
10/1/80	0.11	*	*	*	*		
10/6/80	0.26"	*	*	*	*		
10/15/80	0.26"						
10/20/80	0.54"	79.0	6.20	0	14		- - -
10/27/80	1.20"	15.0	5.44	0	3		
11/3/80	0.15"						
11/10/80	0.17"						
11/19/80	0.75"	3" of snow on ground					
11/24/80	0.30"						
12/1/80	0.90"	29.8	4.37	1	0		- - -
12/8/80	rain gage stolen						
1/6/81	6" of snow on ground						
1/26/81		65.0	3.75	16	0		- - -
2/13/81	*						
2/17/81	.26	37.4	4.30				
3/11/81	0.70"	45.6	3.98	6.4	0		- - -
3/16/81	0.35"						

* insufficient volume of sample

Bedway Site, Fairview, Ohio
Rainfall (cont.)

Date & Time of Collection	inches	S. Cond. umho/cm	pH	Acidity mg/l as $CaCO_3$	Alkalinity mg/l as $CaCO_3$	Sulfate mg/l	Tracer $Br^-F^-I^-$
3/19/81	0.19"						
4/3/81	0.37						
4/19/81	5.67"	47.5	4.01	20.5	0		- -
5/1/81	0.49"	70.0	4.36	12.5	0		- -
5/9/81	0.64"						
5/15/81	0.54"	37.0	4.17	18	0		- - -
5/24/81	0.11						
5/31/81	1.65	45.8	4.2	20	0		- -
6/7/81	2.90	47.9	3.3	20	0		- -
6/16/81	2.75	53	4.06	37.5	0		- - -
6/26/81	3.97	44	3.95	16.6	0		- - -

Results of Field Measurements for Ponds Located on the Periphery of the Basin, For April 3 and 4, 1979

Pond	Temperature °C	pH	Conductivity (umhos/cm)
A	9.1	6.9	700
B (north bank)	8.3	6.9	670
B (east bank)	8.1	6.9	750
C	10.1	5.7	700
D (west bank)	5.7	5.75	250
D (north bank)	5.8	7.1	240
D (east bank)	5.9	7.3	280
D (south bank)	5.9	7.3	280
E	5.8	7.2	250
F	5.8	7.3	250
G (north bank, near iron staining)	5.8	6.4	780